Quality of life and open spaces:
A survey of microclimate and comfort in outdoor urban areas

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Abstract

Recent studies worldwide have indicated the great influence of densely built urban areas on the formation of regional climatic conditions and particularly on the determination of the microclimate. The evaluation of human comfort in outdoor urban spaces and the identification of the parameters determining the microclimate in such areas are among the main aims of the research project "Rediscovering the urban realm and open spaces" (RUROS). Field surveys make it possible to monitor of microclimatic conditions in specific open spaces using a portable environmental monitoring station. In parallel, social surveys, conducted by means of a questionnaire, determine the use and character of the open spaces, the activities carried out, etc., as well as the physical impact of the environment on people. A comparison of the monitoring data with the statistical process of the questionnaires leads to the development of a methodology for mapping comfort in outdoor urban spaces and the ability to propose design guidelines for methods of dealing with the problems that such areas face. The present paper concentrates on the analysis of the morphological parameters of two open spaces in Thessaloniki which determine the microclimate. Furthermore, the human perception of these parameters in relation to people's age, socio-economic status and various activities is investigated.

Conference topic: comfort and quality of indoor and outdoor spaces

Keywords: microclimate, comfort, open spaces, quality of life

INTRODUCTION

Recent studies worldwide have indicated the great influence of densely built urban areas on the formation of climatic conditions and particularly on the determination of the microclimate. The heat islands, which are formed over big cities as a result of the dense urban context, the high concentration of materials with large heat capacity, the heavy traffic and the consequent air pollution, is a simple yet characteristic case. Nowadays it is more than evident that improving the quality of life in urban centers does not require only successful buildings. It requires the inclusion of the voids surrounding buildings and the revitalization of the outdoor spaces in urban areas.

The RUROS project

The evaluation of human comfort in outdoor urban spaces and the identification of the parameters determining the microclimate in such areas are among the main aims of the research project "Rediscovering the urban realm and open spaces" (RUROS), which is a part of Key Action 4 "City of Tomorrow and Cultural Heritage" in the programme "Energy, Environment and Sustainable Development" within the Fifth Framework Programme of the EU. The project is being carried out in eight cities across Europe, in order to produce common guidelines and design tools valid for the whole of Europe.

Each partner has selected two open spaces, where both field and social surveys are being conducted. The field surveys include the monitoring of the thermal, visual and acoustic environment by measuring globe temperature, relative humidity, dry and wet bulb temperature, illumination, air velocity and sound pressure levels. The above parameters are measured sequentially at five fixed points in the open space 3 times per day (morning, noon and afternoon) during one week in each season per year.

In parallel, the users of the open space are asked to fill in a questionnaire, reporting their perception of the thermal, visual and acoustic environment at the time of the measurements. Additionally, information such as the interviewees' age, sex, clothing, activity and other personal information is included in the questionnaire, as well as the reason for being there, their occupation and origin, as part of the social part of the survey.

THE CASE STUDY AREAS IN THESSALONIKI

The Research Team of the Laboratory of Building Construction and Physics (Aristotle University of Thessaloniki) has selected two open spaces for the examination of outdoor comfort conditions. The selection was based on the significant differences between these two case study areas, enabling a more holistic approach to every parameter affecting comfort outdoors.

The first open space, Makedonomahon Square, is located in the city centre and is surrounded by six-, seven- or eight-floor apartment buildings. On the southern side of the square runs Egnatia Avenue, one of the main roads of Thessaloniki, which burdens the area with noise and air pollution. As

shown in Figure 1, the square is of rectangular shape. The vegetation consists mainly of grass, tall trees and some low-height plants. Makedonomahon Square is used mainly as a meeting point for economic refugees, but also children play in the playground and many people cross the square.

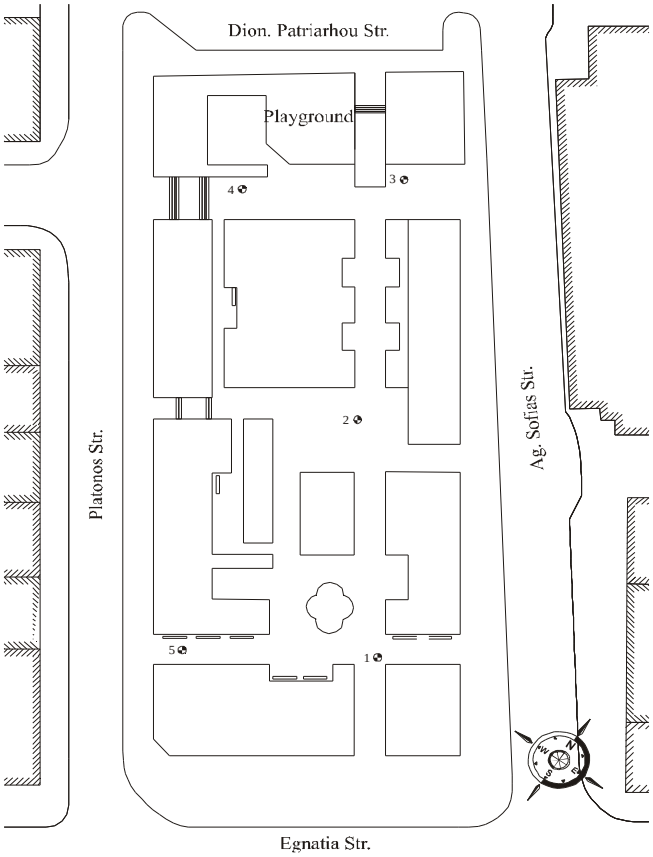

Figure 1. Plan of Makedonomahon Square

In contrast, the second open space selected, Kritis Square, is located in a less noisy environment, in the eastern part of the city. The area is mainly residential with light traffic around the square. The shape of the square resembles a bell (Figure 2) and most of it is shaded by trees of dense foliage. The users of the area are mainly middle-aged citizens, as well as preschool children and their companions, who use the square during the day.

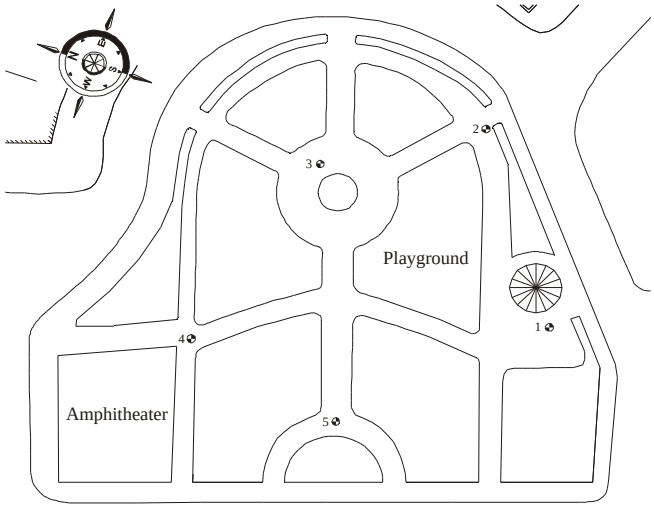

Figure 2. Plan of Kritis Square

THE MICROCLIMATE

The environmental conditions were recorded in both squares at a time step of 5 minutes with the use of a portable environmental monitoring station, designed in an innovative way in order to be carried around the selected measurement points easily and safely. The monitoring equipment consisted of a global thermometer, a psychrometer, a hot-wire anemometer, a luxmeter, a cylindrical luxmeter, a sound analyser and the data-logger (Figure 3).

Figure 3. The monitoring equipment

The autumn field surveys at Makedonomahon Square started on September 1st and lasted until September 7th. The microclimatic conditions recorded during this period in Makedonomahon Square are indicated in Figure 4. In Kritis Square the field surveys started on September 8th and ended on September 17th 2001. Figure 5 shows the hourly distribution of dry bulb temperature and relative humidity in Kritis Square for the period of measurement.

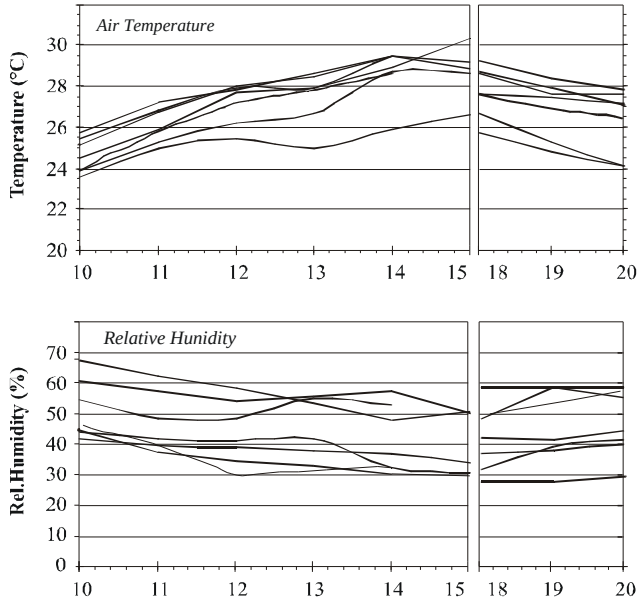

Figure 4. Daily Temperature and Relative Humidity variation during field surveys in Makedonomahon Square.

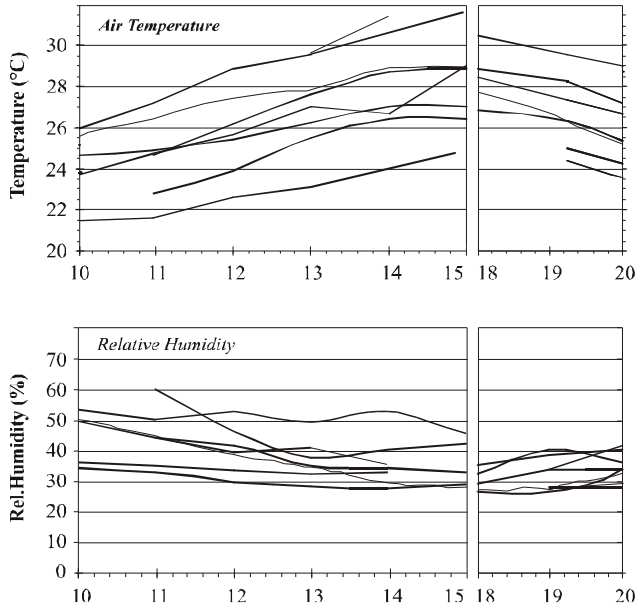

Figure 5. Daily Temperature and Relative Humidity variation during field surveys in Kritis Square.

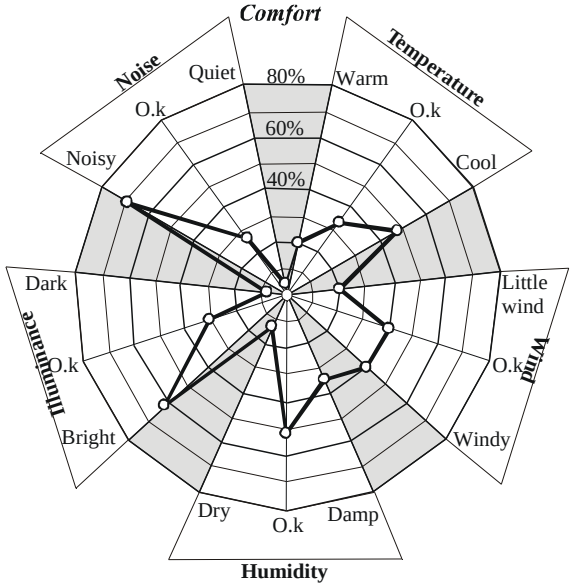

Figure 6. Perception of the environmental conditions in Makedonomahon Square by interviewees feeling comfortable

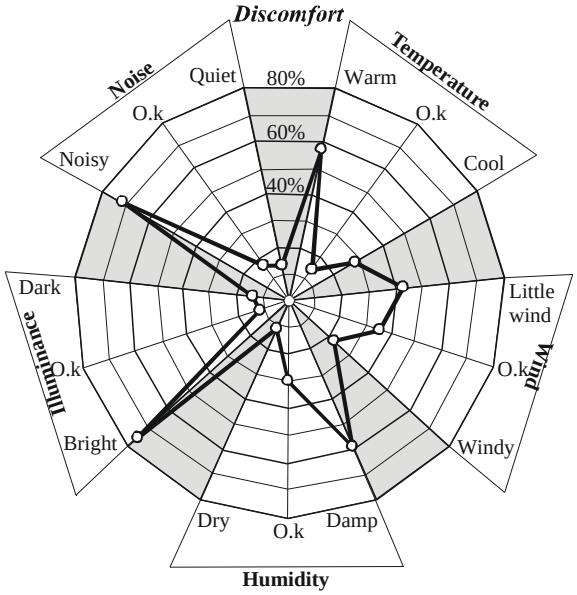

Figure 7. Perception of the environmental conditions in Makedonomahon Square by interviewees feeling uncomfortable

The local climatic conditions during the specific time periods were at normal levels, with the temperature ranging from 24 to 31°C and the relative humidity varying from 30% to 65%. According to the figures, the temperature increases during mid-day hours, while during the same period the relative humidity levels decrease. It is also evident that the daily distribution of temperature levels in Kritis Square is wider than that in Makedonomahon Square. Generally, the temperature levels in Kritis Square reached higher levels during the specific period, probably because of its limited surface and the high adjacent buildings.

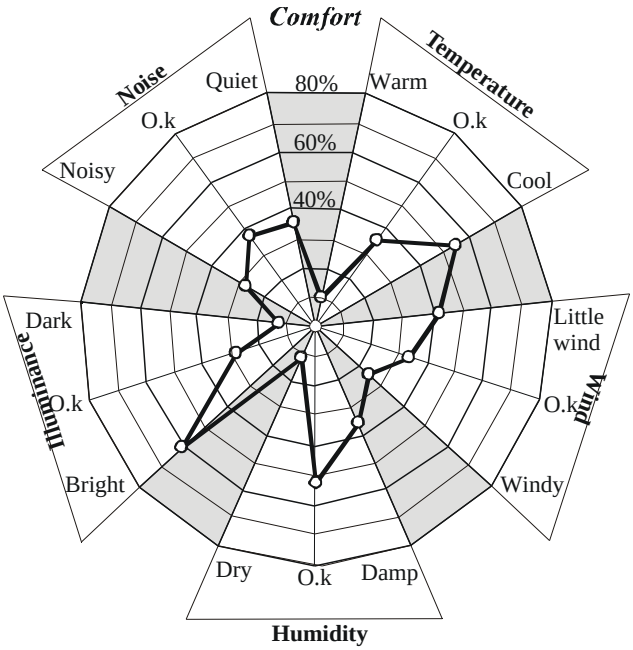

Figure 8. Perception of the environmental conditions in Kritis Square by interviewees feeling comfortable

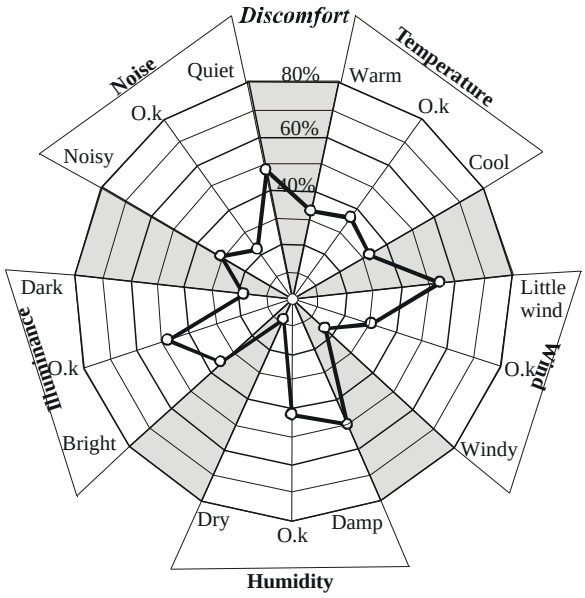

Figure 9. Perception of the environmental conditions in Kritis Square by interviewees feeling uncomfortable

EVALUATION OF COMFORT PERCEPTION

General

During the autumn field surveys at Makedonomahon Square a total number of 312 people were interviewed, 55% of whom were female and the rest 45% male. Their age varied from 10 to over 65 years old, though the dominant age group of the interviewees was 18-44 years old. As regards the occupation of the people using the area, 40% of the respondents were working people; 25% were students, 23% were pensioners, while the rest were engaged in housekeeping. At the time of interview, 62% of the users were walking, 34% were sitting on the benches and the rest were just standing.

The interviewees' perception of the environmental conditions was depicted by the statistical process of the questionnaires. 80% of the area users felt comfortable in general, while the rest expressed dislike of the climatic conditions. The spider diagrams in Figures 6 and 7 show the interviewees' evaluation of the thermal, visual and acoustic environment according to their state of comfort and discomfort respectively. Most of the former felt cool, enjoyed the moderate humidity and the brightness of the day. In contrast, among the people who expressed discomfort, the majority found the temperature and humidity levels high. It is interesting to note that the sound levels were in both circumstances described as high; regardless of their comfort status, most of the interviewees found the acoustic environment particularly noisy. This is substantial evidence of the high sound levels that prevail in the city centre and perhaps an indication that high sound levels do not significantly affect the state of comfort in noisy environments.

In Kritis Square 290 people took part in the survey, equally divided into male and female. Their ages covered a wide range with the majority being between 18 and 44 years old, most of whom were working persons or students at school and university. Of the total number of interviewees, 58% were enjoying sitting on benches, and the rest were mainly walking. Only 37% of the latter were just crossing the square, while all the others were in the square having a walk, talking with other users or attending their children.

The spider diagrams in Figures 8 and 9 show again the actual perception of the thermal, visual and acoustic environment, in terms of the interviewees' general feeling of comfort and discomfort respectively. Statistically speaking, people who were feeling comfortable described the temperature levels at that time as cool, the humidity levels as moderate, and the sound levels neither high nor low. However, those who expressed discomfort found the microclimatic conditions warm and humid, as well as the luminous appearance of the square not bright enough.

In both squares it is worth noting that the majority of the interviewees who expressed a feeling of comfort described the temperature levels as cool. Although the actual temperature in the autumn period did not exceed the customary seasonal levels, most of the people perceived them as pleasantly low. Therefore, it could be assumed that most people enjoy feeling cool in autumn, after the warm summer months.

In order to investigate the parameters determining the comfort sensation, a comparison of objective and subjective data was of great importance. Therefore, the Actual Sensation Vote was compared to the theoretical Predicted Mean Vote, which takes into account the mean environmental conditions monitored during the interview (radiant temperature, humidity and air velocity), the clothing values and metabolic rate of each interviewee [1]. Figures 10 and 11 show schematically the Actual Sensation Vote and the Predicted Mean Vote for the two case study areas.

A great difference between the actual and the theoretical conditions becomes apparent. On average, almost half of the interviewees in both squares voted for the cooler part of the

scale, while the corresponding PMV value is approximately equal to only 5%. In Makedonomahon Square 26% felt warm, while the corresponding percentage in Kritis Square did not exceed 14%. Respectively, the Predicted Mean Votes in Makedonomahon and Kritis Squares are 43% and 38%. On the other hand, the neutral condition, reported as neither cold nor warm, does not reveal such a big variation between the actual sensation and the theoretical mean vote.

The above figures suggest that a purely physiological approach is rather inadequate for describing thermal comfort conditions outdoors, especially in transitional seasons, such as autumn. Although physical adaptation takes place, mainly expressed by the variation in clothing and metabolic rates, the results of the interviews imply that psychological adaptation seems to be equally important.

Psychological adaptation

Psychological adaptation refers to the effects of cognitive and cultural variables and describes the extent to which experiences and expectations alter one's perception of and reaction to the thermal environment [2]. This notion, also sometimes referred to as perceptual adaptation, is described in psychophysics as repeated or chronic exposure to an environmental stressor leading to a diminution in the intensity of the evoked sensations [3], [4]. This simply

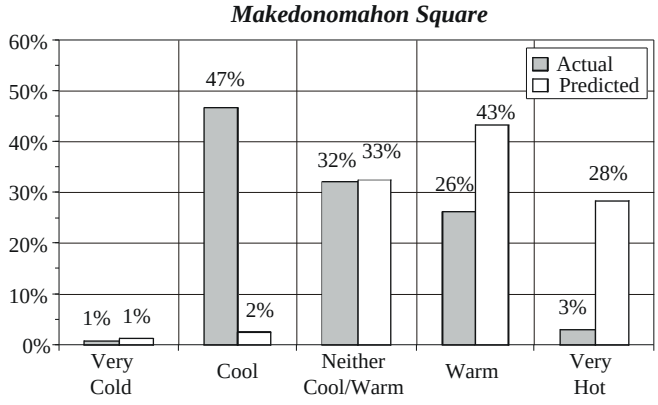

Figure 10. Comparison between Actual and Predicted Thermal Comfort Vote in Makedonomahon Square

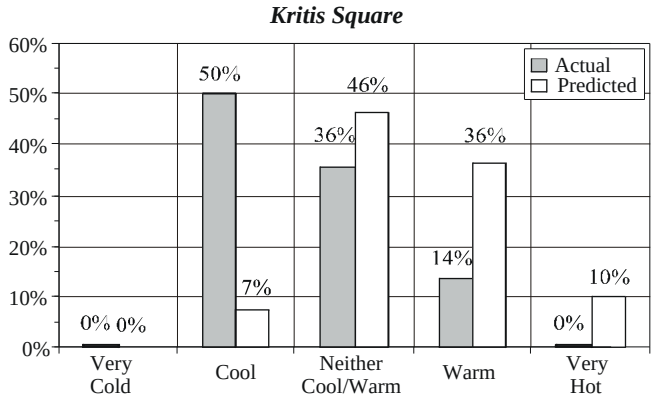

Figure 11. Comparison between Actual and Predicted Thermal Comfort Vote in Kritis Square

means that the human response to physical stimuli depends not only on its magnitude, but is also related to the subjective viewpoints that people have regarding a particular situation. Such psychological factors are expectations, experience, time of exposure and perceived control.

Expectations can greatly influence people's perception of comfort, as they determine what the environment should be, rather than what it actually is [5]. This aspect is reinforced by the frequent reply people gave during the interviews: instead of reporting how they actually felt at the time, they answered "it's OK for this time of year" or "I would prefer it cooler for this season". Additionally, in many circumstances, the sensation votes were influenced by what people had experienced during the previous weeks; summer in Greece is particularly warm, and consequently expectations varied as a result of the much warmer temperatures in the preceding summer. This fact probably explains the disproportion, which appeared in the Actual Sensation and Predicted Mean Votes for the warm and cool categories.

Experience is also a significant parameter of psychological adaptation. It is mainly related to memory and to the schemata people have created in their minds [6]. For example, the climate in Thessaloniki is known to be humid, and no matter what the levels of relative humidity were, most of the interviewees regarded the conditions as damp.

When comfort in outdoor spaces is studied, one must take into account the length of time of the exposure as well, since exposure to discomfort is not viewed negatively if it is of short duration. For example, most of the people who were just crossing the square on their way to a specific destination, felt comfortable, since they anticipated that soon they would be in an artificially controlled environment.

Length of time of exposure is a personal variable; it is dependent on one's personal choices. In contrast, when the duration of their stay in an open space depends on external factors, such as waiting for another person or working, people tend to be less tolerant of the thermal environment. This is related to the perceived control, another primary parameter of psychological adaptation.

CONCLUSIONS

The use and the role of open spaces in cities are affected mainly by their location in the urban fabric (dense city centre or neighbourhood). In the former a great percentage of users pass through the open space without making any other use of it, while in open spaces located in strictly residential areas like neighbourhoods, local inhabitants make extended and more rational use of the space.

As far as microclimatic conditions are concerned, it is obvious that besides the seasonal variation in climatic parameters (air temperature, humidity, air velocity), the microclimate is also affected by the shape of the open space, the vegetation and the area of green surfaces in general, the presence of water surfaces and the surface materials. Microclimatic conditions are also directly related to the extent to which the open space is exposed to wind, which is the main regulator of humidity, sensible temperature etc.

In Mediterranean climates like that of Thessaloniki, it is natural that a temperature variation of 7ºC during morning and afternoon hours (10:00 to 15:00) and even 15ºC during the entire day should influence people's perception of their

thermal environment, as their thermal adaptation during the day can be considered difficult or even unachievable. Furthermore, the combination of high temperature and relative humidity levels during the summer and autumn periods results in an unfavorable evaluation of the thermal environment. However, the interviewees' perception of the prevailing environmental conditions during the field survey period inclines towards the state of comfort This can be attributed to the fact that most of the interviewees had experienced extreme conditions of 35-38ºC and high relative humidity during August.

Understanding and evaluating comfort in outdoor urban spaces is a very complex issue; it requires an understanding of the interrelation between numerous different parameters. This paper has demonstrated that microclimatic parameters strongly affect the state of comfort. Nevertheless, they are not the only determinants for the evaluation of the thermal environment. The differences between the theoretical approach of Predicted Mean Votes and Actual Sensation Votes, as indicated in Figures 10 and 11, could be explained by the great influence of psychological adaptation on the state of thermal comfort. Therefore, design guidelines cannot be based solely on physical parameters; they should also take into account the complex issues of psychological adaptation.

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