A FIRST ASSESSMENT OF THE OUTDOOR CLIMATIC COMFORT IN LISBON

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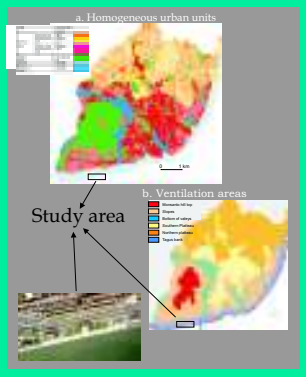
The relation between the climatic conditions and the perception of climatic comfort was analysed in an open urban area in Lisbon. This experiment consisted in simultaneous questionnaire surveys and meteorological measurements during two sunny days. The results showed that in outdoor conditions, thermal comfort can be maintained with temperatures well above standard values defined to indoor conditions. A spontaneous adaptation of clothing seems to exist when a threshold of 31ºC of Physiological Equivalent Temperature is surpassed. Perception of air temperature is difficult to separate from the perception of the global thermal environment and it is modified by others parameters, particularly wind. The perception of solar radiation is related with values of fluxes from different directions (incident on vertical and horizontal surfaces), weighted by the coefficients of incidence on the human body. Wind was the variable most intensely sensed, generally with a negative connotation. The perception of the wind depends largely on the extreme values and wind variability. Women showed a stronger negative reaction to high wind speed than men. The experiment proved that the methodology was suitable to achieve the objectives proposed and it may be applied in other areas and in other seasons.

A view of the study area from the West



A view of the study area from the East

A view of the study area from the South

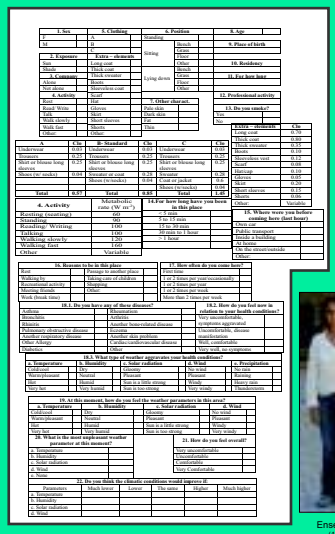
Outdoor climatic comfort is influenced by air temperature (Ta), air humidity, wind speed (v) and radiation fluxes (mainly solar radiation - K) and by a set of personal parameters, such as physical activity, clothing level and age, and also by psychological factors, namely motivation and individual preferences (Nikolopoulou & Steemers, 2003; Stathopoulos et al., 2004; Knes & Thorsson, 2006).

The understanding of the relation between environmental conditions, human characteristics and the usage of open urban spaces can provide the opportunity to **improve open outdoor areas** and contribute to the **design of new and more attractive ones.**

In Lisbon, is being carried an experiment concerning the **perception of outdoor climatic comfort**, as part of the research project URBKLIM: Climate and urban sustainability. Perception of comfort and climatic risks (POCTI/GEO/61148/2004).

The **objectives** of the experiment are: a) to assess the conditions of human comfort in **different outdoor open spaces**; b) to define **thresholds** of outdoor climatic comfort based on the atmospheric conditions, type of activity and individual characteristics; c) to analyse the relation between the perception of climatic comfort and the **microclimatic conditions** in different urban areas. The main aim in this early stage of the project was to define a framework methodology suitable for application in different geographical and meteorological contexts.

The questionnaire was made to young and adult people passing by or sitting on the benches in the study area, engaged in a low or moderate physical activity. The questionnaire was divided in two parts: the first part comprises the individual characteristics of the interviewees and the other part covers their perception of comfort in relation to the meteorological parameters (Nikolopoulou & Steemers, 2003; Stathopoulos et al., 2004).



The questions in the first part included information about gender, age, clothing, among others (see table on the left). The questionnaire included also a list of selected diseases which may be related to atmospheric conditions.
The level of clothing was assessed through a simple scale which defines three types of clothing ensembles and other specific garments, based on the type of clothing people usually wear in this time of the year. It was established a general relation between this scale and the quantification of clothing, in Clo units, based on Parsons, 1993

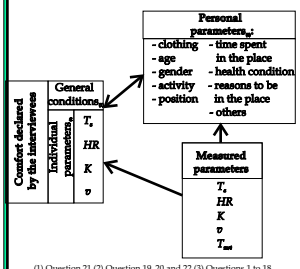
Weather measurements

The field data collection included questionnaire surveys, measurements of weather parameters and collection of photographs of the study area, during sessions from approximately noon till 5 pm. The field studies were conducted in springtime, on the 12th March and 23rd April 2006, both sunny and warm Sundays, with sky partially cloudy, temperatures above the monthly normal and variable wind speed, with maximum value of 6.8 m s^{-1}, and
averages of 1.9 m s^{-1} on the 12th March and 2.6 m s^{-1} on the 23rd April 2006.

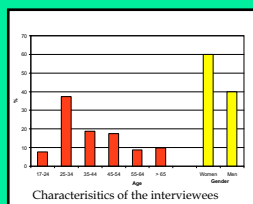
Ensemble A (1 layer) Ensemble B (2 layers) Ensemble C (3 or + layers)

Types of clothing ensembles

The responses to the questionnaire were analysed assuming the possibility of a relation between three groups of parameters (see figure below): the personal characteristics of the interviewees, the perception of comfort revealed by the interviewees and the atmospheric parameters, measured during the interview. The main focus is the relation between the measured atmospheric conditions and the level of comfort declared by the individuals. The thermal influence, obtained from the combination of different atmospheric parameters, was analysed using the Physiological Equivalent Temperature (PET- Matzarakis et al., 1999.



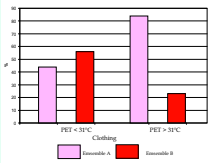
(1) Question 21 (2) Question 19, 20 and 22 (3) Questions 1 to 18



In the two field surveys were obtained 91 interviews. About 55% of the individuals were women. The age of the interviewees varied between 17 and 76 years old and the predominant age group was 25-34 years (37%). All the individuals were performing leisure activities in the area, specially walking, and 25% were seating on the benches. All the interviewees wore clothing included on ensembles A and B with an average Clo value of 0.63.

Characterisitics of the interviewees

The general thermal conditions were, in almost all the cases, considered comfortable, regardless of the broad range of Ta and PET values registered during field work. Motivation and clothing must be considered and can reveal an adaptation to the thermal conditions.

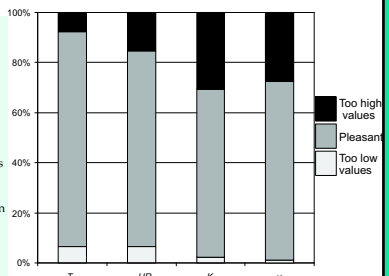


Adaptation of clothing to thermal conditions

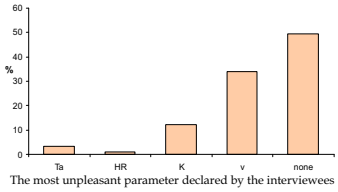
There was a clear differentiation in clothing in periods with PET below and above 31ºC. Below this limit, 56% of the individuals wore clothing ensemble B and 44% wore ensemble A; the average Clo value was 0.67. Above 31ºC, people wearing clothing ensemble A correspond to 84% of the total and the average Clo value was 0.58. The differentiation between the Clo values in these two groups was tested with ANOVA and the result was statistically significant.

The meteorological parameters, when considered individually, were also declared as pleasant in most cases (Figure in the right side). However, some interviewees sensed a specific parameter as unpleasant, which means that people can feel different levels of satisfaction depending on the meteorological parameters considered.

With a Ta variation between 18ºC and 31ºC, 86% of the interviewees declared feeling pleasant. There was no significant statistical relation between the values of Ta measured and the level of satisfaction, which can be partly explained by the interference of other factors in the perception of Ta (e.g. wind) and the confusion between the perception of the overall comfort and of the Ta.

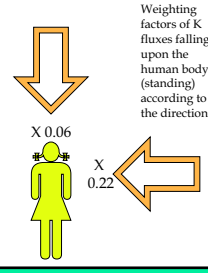


Level of pleasantness declared by the interviewees in relation to each parameter



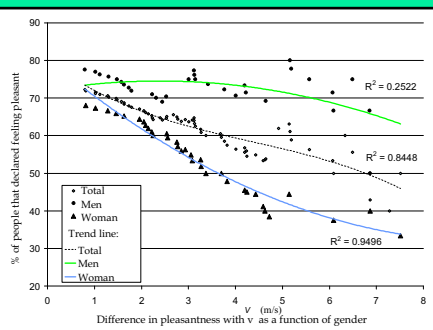
The most unpleasant parameter declared by the interviewees

30% of the interviewees said that K was too strong and 12% said that K was the most unpleasant variable. The human body has more vertical surfaces than horizontal ones, thus, the radiation received by the human body (Kb) was calculated with the values of radiation coming from three directions: K (received in the horizontal surface), KW and KS (coming from west and south, respectively, and falling upon the vertical surfaces) and weighted by the coefficients defined by Fanger (1972): 0.06 and 0.22 for fluxes falling upon vertical and horizontal surfaces respectively. Kb was calculated as: Kb =0.06 K + 0.22 (KS + KW). The relation between Kb and the satisfaction with the solar radiation was statistically



Weighting factors of K fluxes falling upon the human body (standing) according to the direction

Wind results showed the strongest association with the responses obtained from the enquiries. 71% of the interviewees considered the v values as pleasant, while 27% of the individuals said the wind speed was excessive. The values of wind speed differ among the answers that classify wind as pleasant or excessive, specially if we consider the maximum v of the three observations performed for each interview (vmax) and the wind variability, instead of the average speed. An empirical formula was obtained, combining the maximum speed and the variability of the wind, by adding the value of vmax to the standard deviation of the three observations (sv): v = vmax + sv. The differentiation of v in several levels of comfort was statistically significant.



Difference in pleasantness with v as a function of gender

Gender also affects the level of comfort sensed by the individuals in relation to the wind (Figure above). 32% of women affirmed feeling the v unpleasant as opposed to 24% of men. 44% of women declared that v was the most uncomfortable variable, against 21% of men. The level of comfort in relation to wind speed varied according to gender. The Figure (...) shows the variation of the percentage of individuals (women, men and total) that declared satisfaction in relation to the values of v . The increase of v values leads to a rapid decline of pleasant response from women, while the percentage of men is only slightly reduced. This means that women are more sensitive to wind than men, who, in turn, can feel comfortable under a wider range of v values. With values of v higher than 3.7 m/s, over 50% of women declared being uncomfortable, while only 27% of men affirmed being uncomfortable.

CONCLUSION: The results presented suggest that there is a relation between outdoor climatic comfort, the atmospheric parameters and the personal characteristics of the individuals. The individuals inquired in these specific environmental conditions may feel comfortable with temperature values much higher than the values accepted by the traditional models of thermal comfort. It was found a "spontaneous" adaptation of clothing to the thermal conditions; with PET values higher than 31ºC, the dominant clothing changes and the values of Clo are reduced. Ta was found to be difficult to perceive, because it is confounded with the perception of the global thermal environment and it is modified by the others parameters, particularly v. The perception of solar radiation is related with K measured in vertical and horizontal surfaces, when K values are weighted by Fanger's coefficients of incidence on the human body according to the direction. Wind was the variable most intensely sensed by the interviewees and had, in general, a negative connotation. The relation between the individuals that stated the wind as "uncomfortable" (too windy) and the values of v was more significant with the extreme values and wind variability than with the average values. An empirical formula was obtained (vX), combining extreme values with variability and, when applied, it showed a statistically significant relation with the perception by the interviewees. Women demonstrated a stronger negative reaction to high vX than men.
The experiment described provides a framework for further investigation on this subject, considering the possibility to make adequate adjustments.

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