

THERMAL AND ACOUSTICAL PERCEPTION OF LANDSCAPES AT A BRAZILIAN UNIVERSITY CAMPUS

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RESUMO

Due to the role played by environmental comfort in studying the conditions to achieve the human sensation of well-being on the building environment, this subject is usually related to the human perception of the landscape characteristics. Therefore, subjective aspects, psychophysical aspects, social aspects and cultural aspects are often important issues in any environmental comfort evaluation. This research aimed to evaluate the landscape perception and its relationship to thermal and acoustic comfort on a Brazilian University Campus. For this purpose, a collection of data at some of the pedestrians' paths situated in different configurations of this urban site was performed. Based on concepts of sensation, preference and acceptance, a query about subjective perception was developed and applied to the pedestrians. Simultaneously, we also carried a microclimatic data collection with digital sensors of temperature, relative humidity and air velocity and direction. In addition, during pedestrian interviews, a sound pressure meter was applied to measure sound pressures levels (LAeq). Thermal and acoustical measurements associated to the users' interview resulted on a way of qualifying the human experience on the University Campus and revealed the variables influencing on their sensation. These variables were then used in the development of thematic maps which were associated to graphical elements in order to identify and diagnose the landscape features and their relationship to the environmental quality. These maps are important tools on the decision making and planning actions.

1 INTRODUCTION

Environmental comfort evaluation embraces subjective, psychological, social and cultural factors, because human perception is a multisensorial process (Botteldooren et al., 2013). In this context, the local climate and sounds are essential elements for the human perception of the environment.

The thermal comfort is associated to human rhythm and heat exchange, to human sensations and perception, while the acoustical comfort is related to the sound intensity, frequency, composition and time of exposure.

Up to 50% of the users' thermal perception are influenced by subjective factors. The living time in an specific place is also an important element of perception, due to humans' thermal acclimatization and adaptation (Johansson et al., 2014; Sabbag and Fontes, 2014).

Rancura (2011) reports that the identification and users' perception of the environment could offer well-being, and therefore, could influence on his judgement of the environment.

Thus, comparative analysis with different users and landscapes may be a key to understand the effects of climate and sound emissions on the population health.

Taking into account that the thermal and acoustical environment is present everywhere, this paper focus on the pedestrian perception in a Brazilian University Campus, considering the landscape elements and their relationship with the thermal and acoustical comfort outdoors. The research was carried out in path routes, rather than places of permanence.

2 METHOD

2.1 The University Campus

The campus of the Federal University of São Carlos was the study area (Figure 1), which is situated in the city of São Carlos, SP, Brazil. The coordinates of the city is located between 22°30' e 22o30' South Latitude and 47o30' and 48o30' West Longitude, in an average altitude of 846 above sea level. The city has a subtropical climate with dry winters and rainy summers.

Three observation points in the campus area were selected as sample landscapes. Point A, which is situated near the library and close to a bus stop, has a landscape predominantly composed with buildings and impervious surfaces. Point B and C are situated close the sports complex, near a dam, with a predominant landscape of vegetation and pervious surfaces.

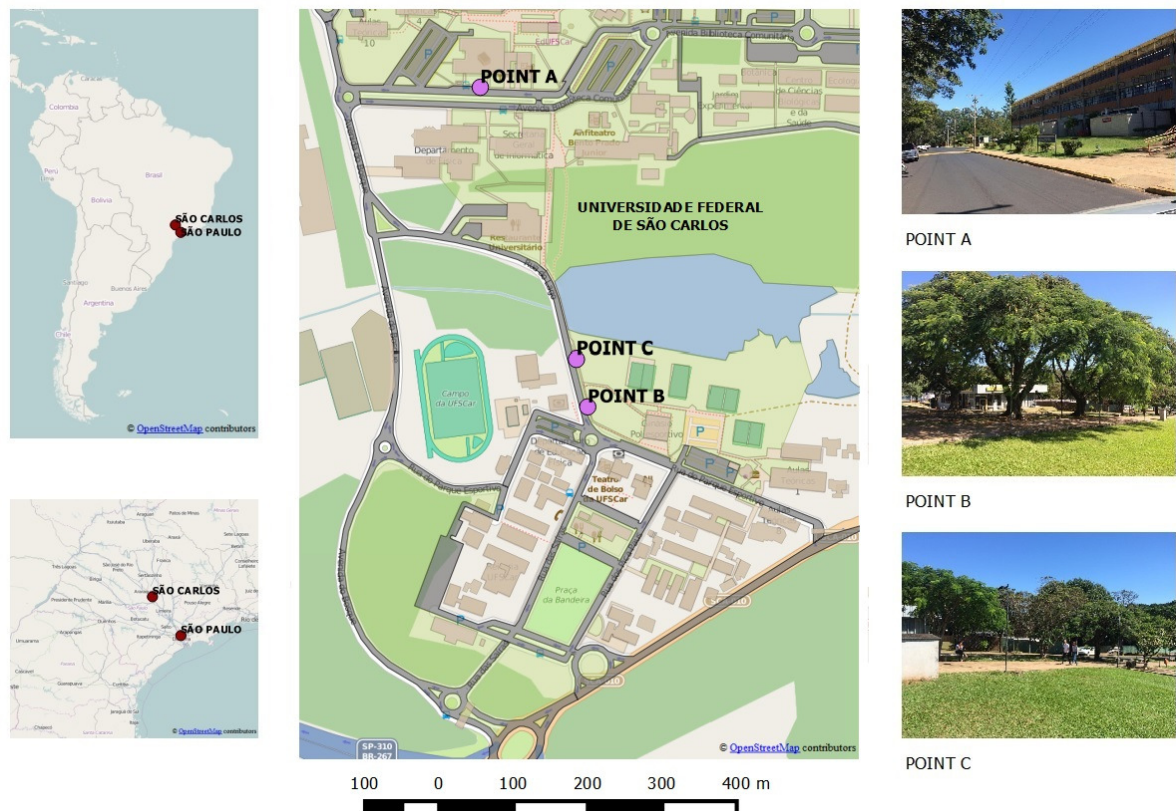


Fig. 2: Map of the Federal University of São Carlos highlighting the collecting points.

2.2 Interview application and analysis

A thermal questionnaire was developed with five sections: demographic data (age, gender, weight and height of the users), profession, living time on the city and last metabolic activity in the last 5 minutes; subjective thermal sensation (users' instantaneous sensation about the air temperature, Linkerd scale for humidity and air velocity); thermal preference (in relation to air temperature, air humidity and air velocity); thermal acceptance (about the temperature in the moment); visual sensation of the landscape (open questions about users' opinion in relation place). Finally, the users were asked about the most meaningful landscape of the place and if this was a negative or a positive feature of the landscape.

The acoustic questionnaire had three sections: instantaneous sensation (users' sensation about the noise in the place); reference sensation (acoustical reference in relation to the noise at home) and perception of the predominant sounds (the users had to classify four kind of sounds from a list presented to them). After the interviews, the answers were numerically codified and inserted in a spread sheet for data treatment and analysis.

2.3 Quantitative Data Collection

Simultaneously to the interview, a data collection of microclimate data was performed (air temperature, relative humidity, air velocity and direction). For this purpose, a Hobo data-logger and a Kimo thermoanemometer VT200F were applied.

For the noise pressure level measurements, the equivalent sound level was registered with a hand-held analyser 2270-L Brüel&Kjær, with wind protector device. The measurements respected the recommendations for outside environmental noise indicated by NBR 10.151 (ABNT, 2000) and ISO 1996.

2.4 Development of thematic maps

Thematic maps about the thermal and acoustical perception of the campus were developed. For the construction of these maps, the software Quantum GIS (QGIS Browser 2.6.0) was applied together with graphical elements. These maps allowed the identification and diagnosis of the landscape in relation to the environmental quality of the campus.

3 RESULTS

The final sample consisted in 52% female and 48% males, with ages between 17 and 44 years old and predominance of students. 57% of them live in the city for more than one year, 43% less than a year and 28% less than one month. For those living less than one year in the city, 71.4% declared some kind of thermal discomfort (Figure 2) in relation to the momentaneous temperature of the air, either by hot (68%) or by cold (4%), while 28.6% of the persons claimed, neither cold, nor hot. When the same question was posed to the group of people living for more than one year in the city, 62% declared some kind of discomfort, being 52% for hot and 4% for cold. In this group, 38% of the interviewees considered the momentaneous air temperature, neither cold, nor hot.

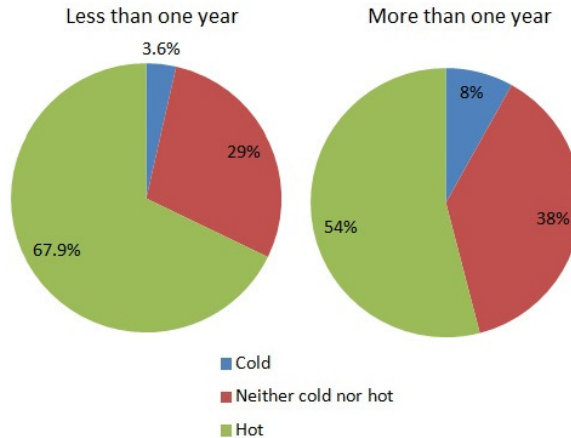


Fig. 2: Sensation to the air temperature in relation to the time living in the city.

About the satisfaction in relation to the air temperature, 76% of the interviewees who live in the city for more than one year expressed comfort, whilst for those living less than one year this value is 68% (Figure 3).

These results confirm the literature in relation to the relationship between the adaption to the local climate and the time of residence in the city. If the person lives more than a year in the city, the probability of expressing comfort is greater than in the group of people living less than a year in the city.

In general, 92% of the total sample considered the air temperature acceptable. However, for the group living more than one year in the city, 24% considered it unacceptable.

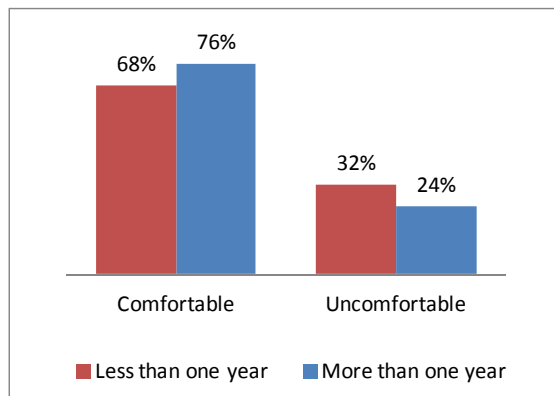


Fig. 3: Answers for the question “Is the temperature acceptable at this moment?”

The temperature under which people express their sensation of thermal comfort varies according to the interviewee. Here the most important factor of influence seems to be the sun exposure. In the group of people answering the questionnaire under direct exposure of sunrays (Points A and C), 69% claimed thermal dissatisfaction by hot and 29% were neutral to this condition (Figure 3). For both points, A and C, the average temperature of the air during the campaign was 27.7° C.

Under the shadow conditions of point B, 54% of the total sample, the answer was, neither cold, nor hot, while 23% answered discomfort by hot, and 23% discomfort by cold (Figure 4). During the campaign, the average air temperature on this point was 24.5° C.

The answers to thermal preference are also influenced by the sun exposure. At points A and C (direct sunrays), 58% had their preference for a colder weather and 38% accepted it as it was, while only 6% had their preference for a hotter weather. On the other hand, at point B (shadows), 76% of the interviewees accepted the weather as it was, 15% had their preference to a colder weather and 8% to a hotter weather.

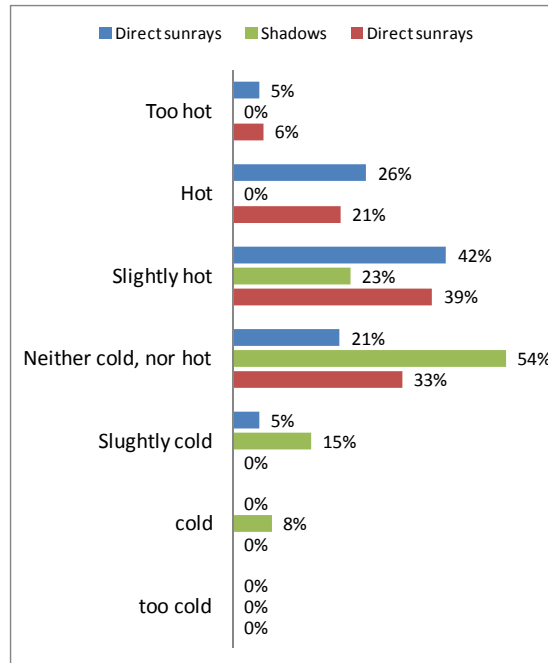


Fig. 4: Answers to the question "At this moment, how do you feel in relation to the air temperature?"

When considering the wind condition at point A, 72% of the interviewees classified it as a light wind, 27% as a moderate and 3% as too windy (Figure 6). The average wind speed during camping on this point was 0,4 meters per second. For point B, 23% of the persons considered it as a light wind, 46% as moderate wind and 30% as too windy (Figure 5). The average wind velocity of point B was 1.4 meters per second. And finally, at point C, the classification of the wind was 32% as a light wind, 42% as a moderate wind and 27% as too windy. In this last point, the average wind velocity was also 1.4 meters per second.

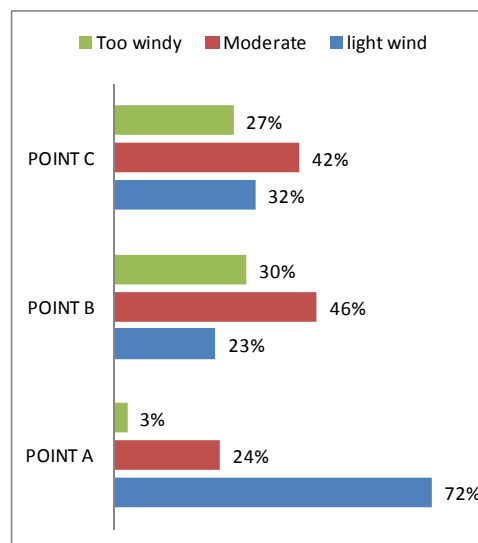


Fig. 5: Answers to the question "At this moment, how do you classify the wind?"

Another important element for the thermal perception was the local landscape. The answers about the most significant landscape at point A resulted in 70% interviewees pointing out the vegetation, 27% the buildings and 3% the ground or pavement. For point B and C, this numbers corresponded to 67% for the vegetation, 18% for the water body, 6% for the buildings and 3% for either the openness of the sky or for the pavement (Figure 6). The vegetation of the campus is perceived by the interviewees as a positive characteristic. They declared more thermal satisfaction with the paths that are surrounded by vegetation than those between buildings or empty spaces.

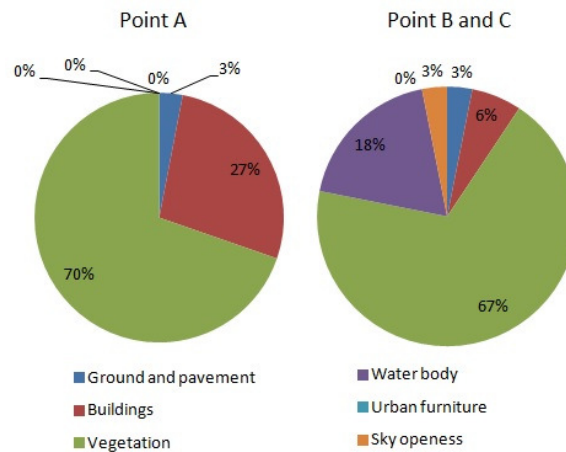


Fig 6: Answers to the question “At this place, which is the most significant landscape?”

In relation to the noise perception at point A, 67% of the sample declared it was, neither quiet, nor noisy, followed by 21% considering it as quiet and 12% as noisy. For points B and C, the answers corresponded to 63% declaring, neither quiet, nor noisy, 22% quiet, 9% noisy, and 6% too quiet (Figure 7). The dissatisfaction in relation to point A is greater than to the others.

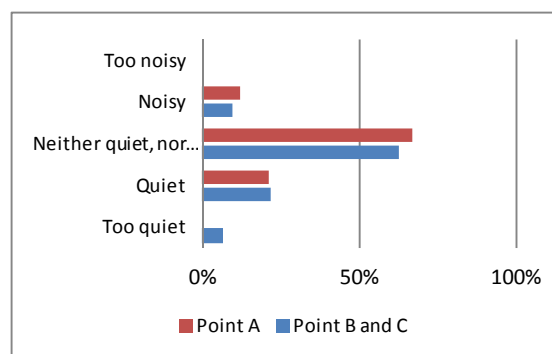


Fig. 7: Answers to the question “At this moment, which is your sensation about the noise in this place?”

Taking as a reference the acoustical environment at home, and comparing it to the campus environment, for point A, 42% of the group answered it was quiet, 30% noisy, 15% neither quiet nor noisy, and 14% too quiet. For points B and C, these values were distributed into, 41% as quiet, 22% as noisy, 19% as neither quiet nor noisy, 13% as too noisy and 6% too noisy. The dissatisfaction in relation to the noise is 30% for point A and

28% for points B and C (Figure 8). These results for the reference environment follow the subjective perception of the local noise.

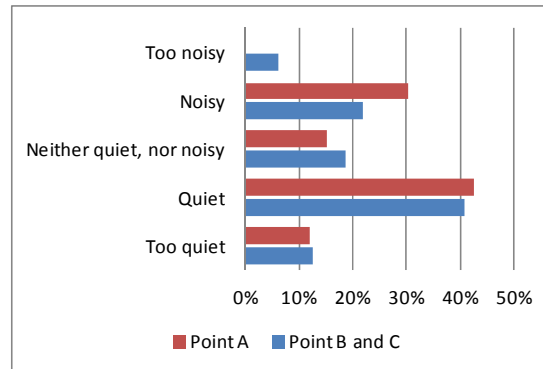


Fig. 8: Answers to question “How do you classify the acoustical environment at home?”

Figure 9 presents the results for the comparison between the classification of the campus noise and the noise at home. At point A, 45% of the interviewees claimed that the campus is noisier than at home, while 32.5% considered that the campus is less noisy and 32.5% declared it as noisy as at home. At points B and C, 38% classified it noisier than at home, 38% considered it as noisy as at home and 25% less noisy than at home.

During all the campaigns the registered equivalent sound pressure levels varied from 52 to 64 dB(A). At point A the pedestrians were exposed to 55 to 64 dB(A), while at point B and C the LAeq varied from 52 to 55 dB(A).

Some studies already demonstrated that the sound pressure level do not totally represent the acoustical comfort, because of the complex interaction among sounds and perceived noise, which depends on the sound sources (Yang and Kang, 2005) and on the introduction of pleasant sounds (You et al., 2010).

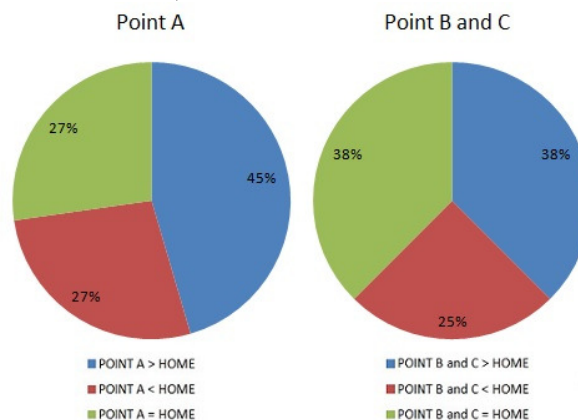


Fig. 9: Comparison between the noise perception at the campus and at home.

We verified some tolerance of the interviewees in relation to the sound levels of the campus. In the rol of sounds identified by the reached 18%, the pedestrian walking 4%, the people talking 4%, and the insects 3%. When considered a classification of indifference, the cars and peoples talking reached the same value of 14%, followed by buses and the pedestrian walking (both with 7%). The unpleasant sounds were classified as 5% for cars, 4% for buses and 3% for site constructions.

All these thermal and acoustical data were applied in the development of thematic maps, to help on the identification and diagnosis of landscape elements and their relationship to the environmental quality (Figure 10). These maps may be used to help on the decision-making in the campus area.

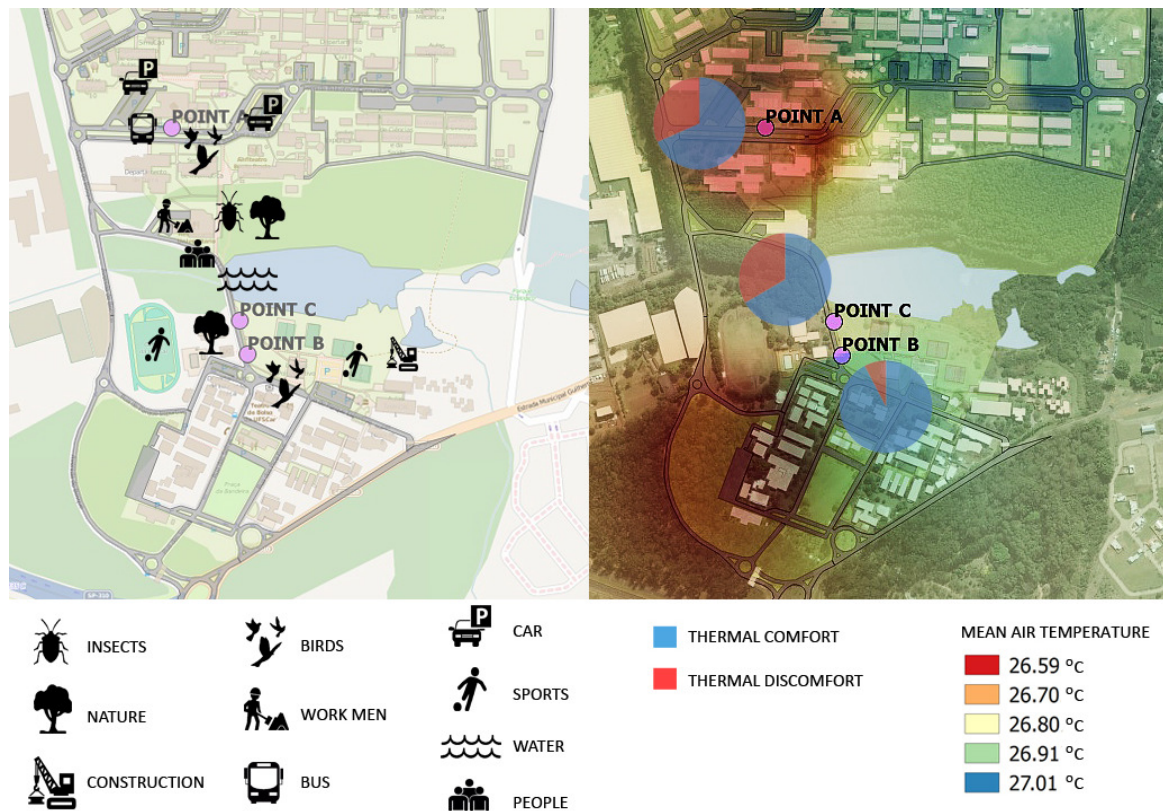


Fig. 11: Thematic map of the acoustical and thermal perception of the University Campus of the Federal University of São Carlos.

4 CONCLUSIONS

The building environment presents thermal and acoustical factors that were perceived and evaluated in different ways by the campus users. This evaluation generated a tool that could help architects and engineering in the decision-making in the campus area. This kind of tool could be used in any urban area of interest.

Most part of the interviewees area students that live in the city for more than one year, and they feel comfortable about the temperature, demonstrating that they are adapted to the local climate. The sun exposure was the most important factor influencing the subjective answers about thermal sensation of the users.

The thermal dissatisfaction was the highest under direct exposure of sunrays. Under shadows of vegetations, the well-being sensation was the largest.

The wind conditions and humidity are also important elements for the thermal sensation of the users. Points B and C, which registered the highest wind velocity, were also the points of less dissatisfaction.

The vegetation was the most significant element of the landscape and considered a positive feature.

In relation to the sound perception, the most part of the interviewees considered the campus, neither quiet, nor noisy. Though the equivalent sound pressure level can be high, the perception of the users about the campus is positive and the presence of birds is taken as a pleasant feature.

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