Correspondences between the conception principles of sustainable public spaces and the criteria of outdoor comfort

Sigrid Reiter[1]

[1]Architecture et Climat, Université Catholique de Louvain, Louvain-la-Neuve, Belgium

ABSTRACT: In a first part, this paper studies the parameters which influence the quality of urban public spaces. Our theoretical study of sustainable public spaces is based on three concepts: the coherent identity of a place, the co-existence (as gathering of differences) and the contextuality (or insertion in its natural, built and human environment). In a second part, this research analyzes the criteria of outdoor comfort. Our comfort approach consists in joining quantitative to qualitative criteria. Physiological comfort criteria must be defined separately according to various types of comfort: thermal comfort, wind comfort, acoustic comfort and visual comfort. On the other hand, our study shows that psychological aspects of human comfort are identical for these various types of physical comfort. Moreover, there are obvious correspondences between the fundamental principles of public spaces quality and the qualitative criteria of comfort. These similarities outline the importance of comfort studies in public spaces and show that outdoor comfort is a question which is not only technical but also architectural. This analysis enables us to work out a strategy of urban planning.

Conference Topic: 3 Comfort and well-being in urban spaces
Keywords: sustainability, comfort, urban planning

INTRODUCTION

Our current development model has generated a lot of environmental and social damage whose extend appears only gradually. These problems decrease our life quality and seriously limit future generations' potential. It is high time that architects and town planners feel responsible for a more harmonious development of our natural and cultural heritage.

Urban public spaces must be comfortable and attractive because it is the place where the collective values are built. However, modern cities have been strongly influenced by economic and technological values. In the past, people used to recognize that buildings have to be adapted to the climate [1]. But, today, outdoor discomfort seems to be the price to be paid for the modern city.

Positive effects of an urban planning that accounts for people's comfort are:

- life quality improvement in cities' public spaces,
- increase of the use of urban squares,
- reduction of buildings and public spaces energy consumption (circulation,…),
- limitation of environmental harmful effects (air pollution, …),
- valorisation of the city's image in order to attract inhabitants downtown.
- …

Cities' sustainable development mainly depends on the capacity of the town planners to offer outdoor urban spaces with high environmental qualities. This positive influence of comfort in public spaces is already recognized in some cities. For example, in San Francisco, the legislation imposes that new buildings do not create awkward shades or wind speeds higher than 5m/s on public spaces, during 90% of time [2].

2. SUSTAINABLE PUBLIC SPACES

2.1 Research method

This study was carried out according to a holistic method, in order to determine qualitative as well as quantitative planning criteria. The purpose of this methodology is to create an architecture better connected to humans and to their environment at the various scales of the built context.

2.2 Sustainability criteria

Sustainable cities offer places to live together and in harmony with our environment, now and in the future. Our public spaces are too often omnipresent carparks or suburban formless deserts. The current problem of our urbanizations is not really a lack of open spaces but rather a lack of public places which enrich life experience downtown [3].

The three major problems of contemporary urban spaces are generally their absence of integration to the local context, their impossibility to connect us and their lack of coherence. This is why we are studying public spaces' sustainability starting from the three following concepts [3]:

- contextuality (as insertion in its natural, built and human environment).
- co-existence (as gathering of differences).
- coherence (as coherent identity of a place).

2.3 Contextuality

Modern physics, philosophy and spiritual traditions agree that, in the universe, the play of the interconnection is fundamental. A square has to connect its specific space with its context, i.e. the physical, built and human environments. This context offers resources, constraints, risks and approvals [4]. A public space must be integrated in its context, benefiting from its resources and being protected from its constraints. It has also to take part in its context, bringing it approvals and causing it any damage. Moreover, each place must also be able to adapt to the context's modifications [5].

To ensure the contextuality of a public space, it is necessary to support:

- its integration, thanks to continuities, respect of the places' memory, … Public spaces must benefit from the context opportunities and be protected from the context constraints, on various scales.
- its participation. A public place brings benefit to the context in which it fits and protects it from any harmful effect that it could induce, on various scales. "I have right to the city" [6] changes into "I am responsible for the city".
- its adaptability. Public spaces have to be able to evolve with their context.

The Mount of Arts (Fig.1), in Brussels, is a good example of contextuality: it creates a connection between the top and the bottom of the city, while offering a pleasant place. On the other hand, the 'place Rouppe' (Fig.2), in Brussels, shows at the same time the lack of architectural integration of a high tower in a dense urban morphology and the absence of participation of this 'carpark square' in the district life.

Figure 1: Contextuality.

Figure 2: A bad example.

2.4 Co-existence

The built environment is a social product and a common resource. Moreover, the city is co-existence: to live downtown means to cohabit [7]. A public place has to create a dense gathering of differences.

Co-existence defines public spaces as collective identities. To ensure the co-existence of a public space, it is necessary to support:

- its gathering, which requires proximity and density. A strong density brings environmental benefit at the planetary level but creates important constraints at the local level. We should increase the density of our dispersed habitat, while paying a special attention with the quality of public spaces.
- its diversity: variety of atmospheres and functions, population heterogeneity, simultaneity or succession of activities, ...
- its opening (i.e. free access, transformation availability, tolerance, …) which offers equality.

Figure 3 gives an example of the concept of urban co-existence. On the other hand, figure 4 shows a counterexample: the pedestrian is completely excluded from this type of town planning, which prevents us from living together.

Figure 3: Co-existence.

Figure 4: A bad example.

2.5 Coherence

A public space becomes really a place when it induces a collective identification [8]. A square can present contradictions if it integrates them in a coherent unit [9].

To ensure the coherence of a public space, it is necessary to support:

- its identity, unit based on a hierarchy, limits, orientation,...
- its significance, which reveals values, symbols, esthetics.
- its naturality, that is the capacity of integration of its various scales, to connect us to our body scale rather than the scale of the machines.

The so-called 'unit' of our suburban areas is unable to found a real coherence based on multiple interactions. The photographs below compare the richness of the true coherence of a complex urban place (fig.5) and the poverty of the false coherence of the zones of dispersed habitat (fig.6).

Figure 5: Coherence.

Figure 6: A bad example.

3. OUTDOOR COMFORT

3.1 Comfort evaluation

The feeling of comfort is the expression of individual's well-being generated by a total perception of his environment. Our approach is based on the microclimatic and acoustic factors intervening in our perception of the environment.

The natural experiment is neither objective nor subjective: it is unaware of any differentiation between body and conscience [10]. Since a few years, the importance of the adaptation in the process of comfort has been largely identified [11], [12], [13]. Moreover, studies showed that people accept much more diverse climatic conditions outside than inside. [13], [14]. Indeed, psychological adaptation is much stronger outside than inside. This adaptability is, however, often forgotten.

We intend to evaluate quantitatively the criteria which influence the pedestrian's physiological balance and qualitatively the criteria which influence their psychological adaptability. This combining of quantitative and qualitative parameters improves the possibilities of outdoor comfort in public spaces.

3.2 Quantitative criteria

The outdoor physiological comfort criteria must be separately defined according to the various types of physical comfort: thermal comfort, wind comfort, visual comfort and acoustic comfort.

3.2.1 Outdoor thermal comfort

Traditionally, there are six parameters to take into account for evaluating physiological thermal comfort [15], [16]: four climatic parameters (air temperature, air speed, radiation and relative humidity) and two physical parameters (activity and clothing).

Most of the recommended comfort indices are worked out for interior conditions and are not applicable outside. Our point of view is that a too complex determination of the physiological outdoor thermal comfort is useless because of the importance of the psychological adjustment process which largely modifies the feeling of comfort.

Two interesting methods are the Olgyay's Bioclimatic Chart [17] and the COMfort FormulA [18], which are based on outdoor studies and not on indoor experiments. These two methods make it possible to quickly determine which parameter can be modified to improve a specific situation.

The graph below (fig.7) gives Olgyay's chart adapted to a moderate European climate.

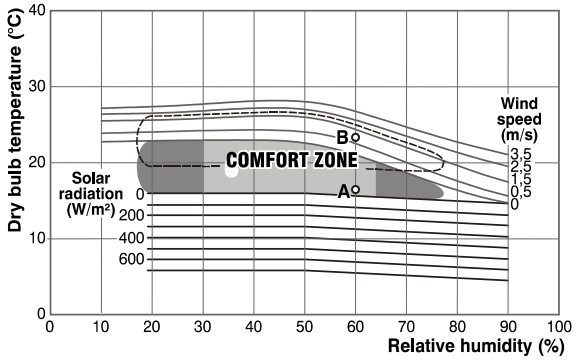

Figure 7: Olgyay's Bioclimatic Chart.

Olgyay's Bioclimatic Chart covers a broad range of temperature, moisture, wind speed and solar radiation levels. The interest of Olgyay's approach resides in combining an analytical and a diagnostic tool. This chart shows how the uncontrollable change of one factor can be compensated for by the controlled variation of another. Moreover, this drawing is very expressive for architects.

It should be noted that Olgyay proposes a bioclimatic diagram encompassing two comfort zones: a summer and a winter zone. This remark shows that he partly takes account of people's adaptation to the season. On the figure 7, point A is in the winter comfort zone while point B is in the summer comfort zone.

For example, with a temperature of 17°C in winter and a relative humidity of 40%, a person is in the comfort zone. But, if this same person receives direct solar radiation of about 500 W/m², the whole of the comfort zone will be lowered to that line and the person is now in a too hot environment. Comfort conditions could be restored either by eliminating this radiation (ie, shading) or by ensuring about 0.5 m/s air movement.

However, Olgyay's tool is too simple. COMfort FormulA [18] is a more precise calculation which utilizes the urban parameters (sky view factor, albedo of surfaces, ...). The COMfort FormulA gives a much more detailed evaluation than the Olgyay's Bioclimatic Chart but requires more computing time.

3.2.2 Wind comfort

For discomfort related to the mechanical effect of the wind, we performed choices among a very great number of criteria presented in the literature. A rule of thumb can be used at first approximation: the average air velocity must be lower than 5m/s. For a more precise study, we choose the two following scientific criteria:

- a limit of discomfort: $P(U + \sigma_u > 6m/s) < Pmax$, with U the mean velocity per hour at 1.5 m of the ground and σ_u the standard deviation due to turbulence. Pmax is a maximum probability of 5% for a long motionless stay, of 10% for a short motionless stay and of 15% to stroll. [19]
- limit of danger: $P(U + 3 \sigma_u > 20m/s) < Pmax$, where Pmax = 4 hours/year. [20]

It is necessary however to keep in mind that, if pedestrians' comfort requires low wind speeds (U < 5m/s), a good ventilation of the street needs a minimal wind speed of 2m/s to ensure air quality.

3.2.3 Outdoor visual comfort

The two major problems of the physiological visual comfort encountered outside are:

- glare risks during the day. Glare often come from specular reflexions of the direct solar radiation on very reflective surfaces.
- bad illumination of public spaces during the night.

3.2.4 Outdoor acoustic comfort

From the quantitative point of view, the equivalent noise levels (LAeq, 8h) must be strictly limited to a value of 65 dB(A) during the day and to a value of 60 dB(A) during the night in all public spaces [21].

3.3 Qualitative criteria

Contrary to the quantitative comfort criteria, the qualitative aspects of outdoor comfort are identical for

the various types of physical comfort. Beyond the subjectivity of human perception, outdoor psychological adaptation depends in particular on the ten following qualitative factors:

- identification of an atmosphere,
- relation with the context,
- continuity of the environmental conditions,
- diversity of the environmental conditions,
- variability of the environmental conditions,
- perception of potential control,
- capacity of adaptation,
- naturality of the place,
- meaning of the place,
- globality of the comfort feeling.

3.3.1 Identification of an atmosphere

Any climatic, visual or acoustic element which helps the pedestrian to be located is a positive factor. For example, without traffic, the sound environments seem strongly related to urban typologies; this sound identification of the urban fabric contributes to a better appreciation of the site. Circulation downtown unfortunately covers often these sound differences and thus hides the influence of urban morphology on the identity of the soundscape [22].

Moreover, coherence between the sound and visual environments is an important factor for human comfort [23]. We should thus create visual, sound and climatic urban atmospheres which translate the place identity.

3.3.2 Relation with the context

Oseland has proved that thermal comfort depends on the context: in their houses, people accept a comfort temperature which is 3°C lower than in a climatic room [24]. It is obvious that people become even more tolerant in outdoor conditions. In addition, from the acoustic point of view, Gustavino has showed that the human subject appreciates differently the same sound following the context of listening [25].

Since comfort is strongly contextual, no decision can be made to improve comfort in a public space without holding account of the temporalities of the place, its localisation and its usage. There is no valid solution for all situations: each project must be imperatively integrated in its context.

3.3.3 Continuity of the environmental conditions

The presence of two very different levels of brightness, adjacent in the visual field, is a source of discomfort and decreases the eyes' capacities [26]. Disturbing noises are less tolerated in a calm environment than in presence of a higher background noise [27]. People better accept homogeneous high wind speeds than less strong winds presenting important speed variations [28],[29].

An abrupt change in the environment is always difficult to accept. We should promote continuity of the environmental conditions, i.e. avoiding too strong contrasts, spatially and temporally. It is thus advised to create transition zones, so that the passage from a zone where people feel comfortable to a less neutral environment is done imperceptibly.

3.3.4 Diversity of the environmental conditions

A study of Nikolopoulou and Steemers on public places shows that squares offering zones with shade and sun are used for a longer time than those presenting only one of these conditions [30].

Someone may prefer either to sit in the sun or in the shadow of a building, refreshed by a breeze or protected from the wind, in contact with the sky or under arcades, ... The cities can be designed to provide these choices, even if some areas will be preferred at certain seasons or times of the day.

Let us introduce diversity in the environmental conditions of each place and in the atmospheres of public spaces located in the vicinity. Our objective is thus to create a varied environment, offering multiple choices to pedestrians.

3.3.5 Variability of the environmental conditions

A variable environment is often preferred to a static environment. Let us note that the daylight is always preferred to artificial lighting because of its variability [26]. In addition, environmental stimulation is one of the goals for which people go outside [13].

Need for variability is especially necessary to people who pass a great part of the day inside a monotonous room. Citizens' holiday choices expose them frequently to high levels of discomfort: for example, taking the sun under burning solar radiation. This phenomenon can be explained because these conditions create a salutary contrast compared to our artificial buildings [11].

We should create openings to changes in our urban public spaces.

3.3.6 Perception of potential control

The perception of possible control is an important comfort parameter. Paciuk affirms that unpleasant stimuli are less irritating when the subjects perceive that they can control them [31]. Environmental adaptability in public spaces increases users' impression of control. Interactive adaptation seldom takes place outside, but movable components, such as parasols or windbreaks, can provide spatial and temporal variations.

3.3.7 Capacity of adaptation

The comfort felt in a public space depends on the capacity of the users to adapt to their environment. There are many elements which influence the psychological perception of our adaptation capacities: pedestrians' forecasts, their motivation to be there, short duration of exposure, … But, the most important criteria is the possibility of moving towards another type of environment [30]. Public spaces with varied environmental conditions, on the same place or in the vicinity, give an opportunity of adaptation.

3.3.8 Naturality of the place

Many studies show that natural elements are beneficial for humans. For example, natural light is better adapted to human eye than artificial light is [26] and natural sounds are preferred to artificial ones [23].

Modern life isolates us more and more from the natural world. We should increase the natural character of our public spaces. There are various types of natural elements which can easily brighten an urban environment: climatic elements, vegetation, water surfaces, ... For example, fountains introduce a natural sound environment, while creating a mask for the traffic noise. But we can also conceive spaces that offer similar characteristics to those provided in the natural world. An essential characteristic of the nature is its cyclic operation, which is important for our psychic balance.

3.3.9 Meaning of the place

The meaning character of a place influences people comfort. For example, acoustic comfort depends on the possibility of understanding the sound [27]. The quality of the sights offered to pedestrians is a major element of visual comfort [26].

Moreover, aesthetics, values and symbols are necessary to all humans. If the same technical choice can be translated various ways, we should always select the solution which allows a symbolic appropriation.

3.3.10 Globality of the comfort feeling

Comfort is a feeling coming from a total perception of our environment. Taking account of the whole qualitative and quantitative comfort criteria and their interactions ensure the most advantageous situation for the space users. For example, vegetable windscreens are generally preferred to artificial systems. However, this assertion is false when the noise level is very high: in this case, the lack of coherence between the noise and the visual environment cancels the positive influence created by vegetation [32].

3.4 Some conception tracks

In spite of the complexity of the interrelations above, it is possible to consider some conception tracks to increase pedestrians' comfort in a public space:

- modifying its physical parameters to change the microclimate or the noise level.
- developing the specificities of the place.
- ensuring coherence between the various types of environmental stimulations, for example the sound environment and the vision.
- taking account of the space users.
- developing activities adapted to the place.
- creating transition zones to attenuate contrasts.
- proposing several atmospheres in the same place: shadow and sun, wind and shelter, ...
- creating environmental conditions different from that of the public spaces located in the vicinity.
- increasing the perceived control, for example by devices such as parasols.
- developing the naturality of the place.
- exploiting the meaning quality of this environment.
- ensuring balance between these various comfort criteria.

4. CONCEPTION STRATEGY

4.1 Similarities between comfort and sustainability

The comparison between the sustainable qualities of public spaces and the qualitative comfort criteria is astonishing: these criteria are really similar. We can thus create a table of correspondences (see table 1).

Table I: Correspondences between the fundamental principles of sustainable public spaces and the qualitative criteria of outdoor comfort.

Sustainable public space		Comfortable environment
Coherence	Identity	Identification of an atmosphere and globality of the feeling of comfort
	Significance	Meaning of the place
	Naturality	Naturality of the place
Co-existence	Gathering	Diversity of the environmental conditions on a place
	Diversity	Diversity of atmospheres in the surroundings
	Opening	Variability of the environmental conditions
Contextuality	Integration	Relation with the context and continuity of the environmental conditions
	Participation	Capacity of adaptation
	Adaptation	Perception of potential control

These obvious correspondences outline the importance of comfort studies in public spaces and show that outdoor comfort is a question which is not only technical but also architectural.

4.2 Strategy for sustainable public spaces

Thanks to these similarities between sustainable public spaces' principles and outdoor qualitative comfort criteria, we can work out a strategy of urban planning, based on three principles which are coherence, co-existence and contextuality.

Any public space must create a sustainable place,

- creating a place,
  - revealing an identity,
  - giving significance,
  - supporting naturality,
- creating co-existences,
  - gathering differences,
  - offering diversity,
  - being open,
- forming part of its context,
  - being integrated,
  - taking part,
  - allowing adaptations.

CONCLUSION

Our study of the parameters which define the sustainability of urban public spaces has underlined three fundamental qualities: the coherent identity of a place, the co-existence (as gathering of differences) and the contextuality (or insertion in its natural, built and human environment).

Adaptation is very important in the outdoor comfort process. Outdoor comfort can only be defined by a combination of qualitative and quantitative criteria. We affirm that the physiological comfort criteria of public spaces are different according to the various types of comfort but that the psychological aspects of human comfort are identical for these various physical comfort. We raised ten parameters which significantly influence the qualitative evaluation of pedestrians' comfort: identification of an atmosphere, relation with the context, continuity, diversity and variability of the environmental conditions, perception of potential control, capacity of adaptation, naturality and meaning of the place, globality of the comfort feeling. Town planners should take account of all these parameters to improve quality of our cities.

There are obvious correspondences between the fundamental principles of sustainable public spaces and the qualitative criteria of outdoor comfort. This analysis enables us to work out a strategy of urban planning, based on contextuality, co-existence and coherence. The apparent superficiality of the concept of comfort dissimulates thus a considerable richness.

ACKNOWLEDGEMENT

This research has been financed by Brussels ("Région de Bruxelles-Capitale").

REFERENCES

[1] G. Escourrou, Le climat et la ville, Nathan Université, 1991.
[2] P. Bosselmann, K. Dake, L. Fountain, L. Kraus, L. Harris and A. Harris, Sun, Wind and Comfort: Study of Thermal Comfort in San Francisco. Berkeley: Centre for Environmental Design Research, University of California. 1988.
[3] S. Reiter, L'influence du microclimat sur le confort des piétons pour des espaces publics durables, mémoire de DEA, UCL, 2003.
[4] A. Berque, Médiance, de milieux en paysage, GIP RECLUS, Montpellier, 1990.
[5] J. de Rosnay, Le macroscope, vers une vision globale. Editions du Seuil, Paris, 1975.
[6] H. Lefebvre, Le droit à la ville, Editions Anthropos, Paris, 1972.
[7] P. Ansay and R. Schoonbrodt, Penser la ville, Archives d'Architecture Moderne, Bruxelles, 1989.
[8] J. Remy and L. Voye, Ville, ordre et violence, Presses Universitaires de France, Paris, 1981.
[9] P. von Meiss, De la forme au lieu. Une introduction à l'étude de l'architecture, Presses polytechniques et universitaires romandes, Lausanne, 1993.
[10] C. Norberg-Schulz, L'art du lieu. Architecture et paysage, permanence et mutations, Le Moniteur, Paris, 1997.
[11] N. Baker, We are all outdoor animals, Proc. PLEA 2000. London (2000).
[12] R. de Dear Richard, G. Brager and D. Cooper, Developing an Adaptive Model of Thermal Comfort and Preference, ASHRAE RP- 884, 1997.
[13] M. Nikolopoulou, N. Baker and K. Steemers, Thermal comfort in outdoor urban spaces: understanding the human parameter. Solar Energy 70 (2001).
[14] P. Höppe, Different aspects of assessing indoor and outdoor thermal comfort. Energy and Buildings 34 (2002).
[15] B. Givoni, Man, Climate and Architecture, Elsevier Architectural science series, UK,1969.
[16] P.O. Fanger, Thermal comfort, analysis and applications in environmental engineering, Mc Graw-Hill Book Company, USA, 1970.
[17] V. Olgyay, Design with climate, bioclimatic approach to architectural regionalism. Princeton university press, New Jersey, 1963.
[18] R.D. Brown and T.J. Gillespie, Microclimate Landscape Design, creating thermal comfort and energy efficiency. John Wiley & Sons, Canada, 1995.
[19] J. Gandemer, Aerodynamic studies of built-up areas made by CSTB at Nantes, J. Ind. Aerodyn. 3 (1978).
[20] M. Bottema, Wind climate and urban geometry, Technische Universiteit Eindhoven,1993.
[21] IBGE-BIM and AED-BUV, La lutte contre le bruit en milieu urbain dans la région de Bruxelles-capitale, Les Carnets de l'Observatoire, Bruxelles, 1998.
[22] C. Sémidor,"In town without my car!": a new urban soundscape, PLEA 2003, Santiago, 2003.
[23] J.L. Carles, I.L. Barrio and J.V. de Lucio, Sound influence on landscape values, Landscape and urban planning 43 (1999).
[24] N.A.Oseland, A within-groups comparison of predicted and reported thermal sensation votes in climate chambers, offices and homes. Healthy Buildings 1 (1994).
[25] C. Gustavino, Perception of Background Noise, Urban Soundscapes, Nantes, 2001.
[26] S. Reiter and A. De Herde, L'éclairage naturel des bâtiments, Ministère de la Région Wallonne, Namur (Belgium), 2001.
[27] M. Blasco, Cours d'acoustique, UCL, 2001.
[28] W. H. Melbourne and P. N. Joubert, Problems of wind flow at the base of tall buildings. Proc. Int. Conference on Wind Effects on Buildings and Structures, Tokyo, 1971.
[29] M. Bottema, A method for optimisation of wind discomfort criteria, Build. and Env. 35 (2000).
[30] M. Nikolopoulou and K. Steemers, Thermal comfort and psychological adaptation as a guide for designing urban spaces. Proc. PLEA 2000. Cambridge (2000).
[31] M. Paciuk, The role of personal control of the environment in thermal comfort and satisfaction in workplace, in Coming of age, USA, 1990.
[32] M. Louwers, Caractérisation de la qualité perçue du bruit routier. Acoustique & technique 26 (2001)