Soundscape quality of urban parks and gardens

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Summary

Nowadays, many studies show that in urban environments, parks and gardens are acclaimed for the quality of their soundscape. The purpose of this study is to accurately identify the specific sound qualities of these places. The first assumption of this study is that landscape design of parks and gardens and their integration into the urban environment may induce specific sound qualities. Thus, a selection of four parks and gardens with representative landscape structures of the other Parisian parks has been made to conduct this study. Then, the selected parks are divided into landscape's sub-entities which constitute the spatial units of the study. For each studied location, ten semi-structured interviews are made with the users. According to the principles of an inductive methodology, there is no a priori assumption about the nature of their sound experience. From these data both qualitative and quantitative analyzes are made. A first qualitative analysis reveals a set of descriptive units which are expressed by the users. A second one identifies three major themes that structure descriptions of the sound environment: The presence of the city, the human presence, and the presence of the nature. From these data, a Principal Component Analysis highlights the recurrences and associations of descriptors by showing major themes. Those themes illustrate how the gardens are distinguished from each other on a perceptual point of view. The last step of the analysis compares the perceptual data to acoustic measurements with linear correlations.

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1. Introduction

Nowadays, many studies show that in urban environments, parks and gardens are acclaimed for the quality of their soundscape [1,2,3]. Most of these studies derived from the European directive 2002/49/CE on the management of environmental noise which requires quiet areas to be identify for preservation and recovery. A large part of these studies defines the calm from a perceptual, semantic or acoustic point of view [4,5]. Another part identifies quiet areas geographically, in terms of location. Both highlight the plebiscite for the sound quality of the gardens. The purpose of this study is to accurately identify the specific sound qualities of these places, and to work on the relation between soundscape and the landscape structure. This paper focuses on the evaluation of garden soundscape qualities and proposes to determine the acoustic measurements that could match with the users perception.

Jeon and Hong worked on a series of parks and gardens which are located in Seoul and showed that users distinguish garden sound environments from categories of sound sources. According to their study, gardens differ in three main categories: the gardens dominated by urban sound sources (traffic noise), gardens dominated by the human sound sources, and finally, gardens dominated by natural sound sources. This study used the soundwalk method. Each participant answered a questionnaire with closed questions about the agreement, the noise level or the sound sources [6].

Considering however that the sonic environment of parks and gardens should be explored in an interdisciplinary context combining humanities and acoustics, it was decided to make no hypothesis on the perceptual categories of park and garden users. Therefore this study falls into the paradigm of the grounded theory [7].

2. Methods

2.1. Experiment procedure

2.1.1 Choice of location

Locations are defined according to their architectural and landscape diversity. A selection of 6 parks and gardens has been made. Their landscape structures are representative of

the majority of Parisian parks. Parks are divided into landscape sub-entities which then constitute the spatial units of the study. In total 23 landscape sub-entities have been selected.

2.1.2. Interviews

According to the different functional, sensitive, or symbolic expectations of the users, the perceived qualities of the soundscape may differ. For each location studied, 10 semi-structured interviews were made with the encountered users. Consequently, a total of 230 interviews with duration of 10 to 20 minutes were conducted. According to the principles of an inductive methodology, there is no "a priori" assumption about the nature of the sound experience of the users. There is no question about agreement or disagreement, on sound sources or on the sound level. Users are just invited to talk freely about the sound environment.

2.1.3. Acoustic measurements

In each location measurements were also carried out. Duration and periods of the measurements followed the recommendation of Brocolini [8]. His study shows that the optimum measurement duration in a urban garden could be limited to 10 minutes if the measurement is conducted between 10AM and 6PM. In this study the acoustic indicators which characterize the soundscape are limited to the equivalent sound level, percentile levels such as L95, L90, L50, L10, L5, and the dynamic indicator L10-L90. The sound level of each sound sources and their cumulative duration of presence are also calculated.

2.2. Analysis

2.2.1. Interviews

First, interviews were analysed with the "table and cisors" method (la table et les ciseaux), which has been developed by Chalas [9]. This qualitative method makes it possible to read the user's speech with synchronic and diachronic approach. In the following text, every argument, idea, or way to describe the sound experience is referenced as a "descriptor".

2.2.2. Principal Component Analysis

For each location, the number of interviewed persons who freely used a descriptor to characterize the soundscape was counted. For each location 10 interviews were conducted. A descriptor can then appear between 0 and 10 times. The postulate is that the more important an idea, the more shared by a large number of users. This counting provided the input data of the Principal Component Analysis on the entire corpus. Descriptors are the variables of the PCA, whereas locations are the objects. PCA has been used to identify recurrences and associations of descriptors. It allows simplifying the analysis by identifying major themes. The themes illustrate how the gardens are distinguished from each other on a perceptive point of view.

Finally, the measurements carried out at each location were projected on the results of the PCA with Pearson correlation coefficients. The purpose is to identify measurements that correspond to the perceptual characterization of the sound environment revealed by the interviewed persons.

3. Results

3.1. Qualitative Data Analysis

The first step of the analysis makes it possible to identify a series of descriptors which are the descriptive units of the sound environment extracted from the user's speech. Descriptors expressed by users are divided into different categories. Some descriptors refer to acoustic phenomena such as transparency and sound insulation, while others are more complex perceptual phenomena. Thus, users express themselves about their feeling of expansion or tightening of the sound space: extent or restriction feelings. For example "Limitation" is a feeling of garden noise limits: the visual environment can sometimes give the feeling that the garden extends, while the presence of urban traffic noise will remind users that the garden is limited. Other descriptors express the confrontation between different categories of sounds: for example users can feel the shift due to the presence of urban sound sources in a natural looking environment. Finally, some descriptors express a distinction between two different precise locations: for example, some users have the idea that the soundscape of the garden contrasts with outdoor sound environment. In other cases, some users express that the soundscape of a specific place in a garden contrasts with the sound of another one in the same garden.

Descriptors of the visual environment and descriptors of the users' tactics have also been identified. Elements related to the visual environment concern the landscaping of the garden, while tactics refer to the way users choose their sonic environment: what they are looking for or what they avoid. For example, the

"intimacy" tactic is as much a research of few human sound sources, as a research of places where users can speak without being heard by other people (Figure 1). Figure 1 presents all the 35 descriptors extracted from the users' discourses.

Sound environment

Acoustic phenomena	**Enlargements**
- Isolation	- Extent
- Transparency	- Sound perspective
	- Concentration

Shrinkages	**Confrontations**
- Limitation	- Compensation
- Tightening	- Held in the city
	- Gap
	- Splitting

Distinction	**Fusion**
- Contrast	- Envelopment
- Transportation	- Attraction
- Protection	- Focus

Visual environment

- Closed
- Integrated
- Perspective
- Hidden
- Concentric
- Open
- Geometric
- Natural

Tactics
- Freedom
- Proximity
- Visual preference
- Change of scenery
- Inclusion
- Integration
- Social observation
- Control
- Exclusion
- Intimity

Figure 1. Sonic and visual descriptors and users' tactics extracted from the qualitative data analysis.

Second step of the qualitative analysis highlights that users refer to the quality of the sound environment with three categories of sound sources: urban sound sources, human sound sources and natural sound sources. When they speak about insulation or acoustic transparency, they refer to certain sound sources. As well when they express the idea of extent or on the contrary the idea of tightening, they refer to certain sound sources. In this regard, the analysis shows that extent feelings are associated with a positive appreciation of the sound environment, and they always refer to deemed positive sound sources such as natural or human sound sources. On the contrary, feelings related to tightening refer to negative appreciations of the sound environment and to negatively perceived sound sources: human sound sources or traffic noise. Actually, human sound sources are negatively as well as positively assessed depending on the context. At the end of this second part of the qualitative analysis, referenced descriptors are developed for each corresponding sound sources. Then, insulation can be summarized as follows: insulation from urban sounds and insulation from human sounds. Finally, in line with many studies, this analysis shows that the expression of the sound perception begins with the identification of sound sources [10].
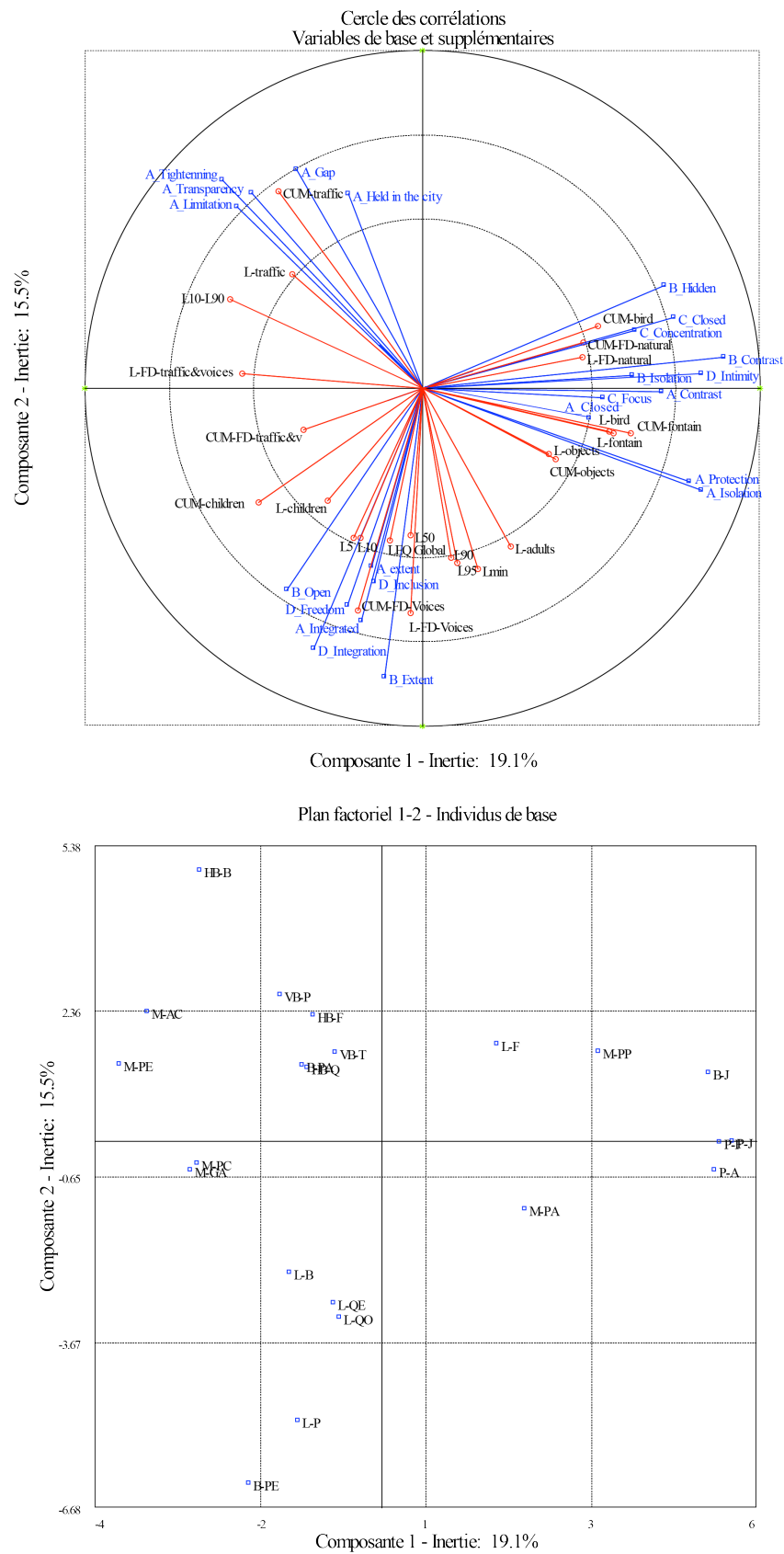
3.2. PCA Results

The ACP proposes to analyse 12 axes with eigenvalues greater than 1. Only 3 axes explain respectively 19.1%, 15.5% and 9.4% of the total variance and can be analysed as continuous perceptive dimensions.

First axis highlights that garden soundscapes are characterized mainly by their relationship with the urban sounds. On one side there are the "contrast", the "insulation", or the "protection" from urban sound sources, and on the other side there are the "limitation", all the tightening feelings, or the sound "transparency" from those sounds. In this axis, the gardens are distinguished by their vulnerability or their protection from the urban environment.

Second axis is linked to the sociability in the garden. This axis is related to various phenomena that distinguish intimate locations from social places. In the intimate locations, the human presence is very rare and users are looking for loneliness, whereas in the more social places, the users like the feeling of being surrounded by the human presence and the sounds it produces, they don't feel oppressed by those sounds (Figure 2). Gardens are places of privacy or sociability. Users express in different ways the sonic relationship to the others.

Finally, the third axis seems to be linked with the garden aesthetic. On one side there are gardens with a natural aspect, where the users express the feeling to be enveloped by the sound environment and the feeling of escape from the city. On the other side there are the more geometrical gardens, open on the city with visual perspectives but also with sort of sonic perspectives which offers an aesthetic perception of urban sounds. Then, the garden can be a place of immersion in nature, or it stages the city as a landscape to contemplate or a soundscape to listen (Figure 3).

All the other axes are not continuous and explain only specificities of individual parks.

Figure 2. On top (2a) Descriptors and acoustic indicators, at the bottom (2b) position of the garden landscape sub-entities in the perceptual space on the two first dimensions.
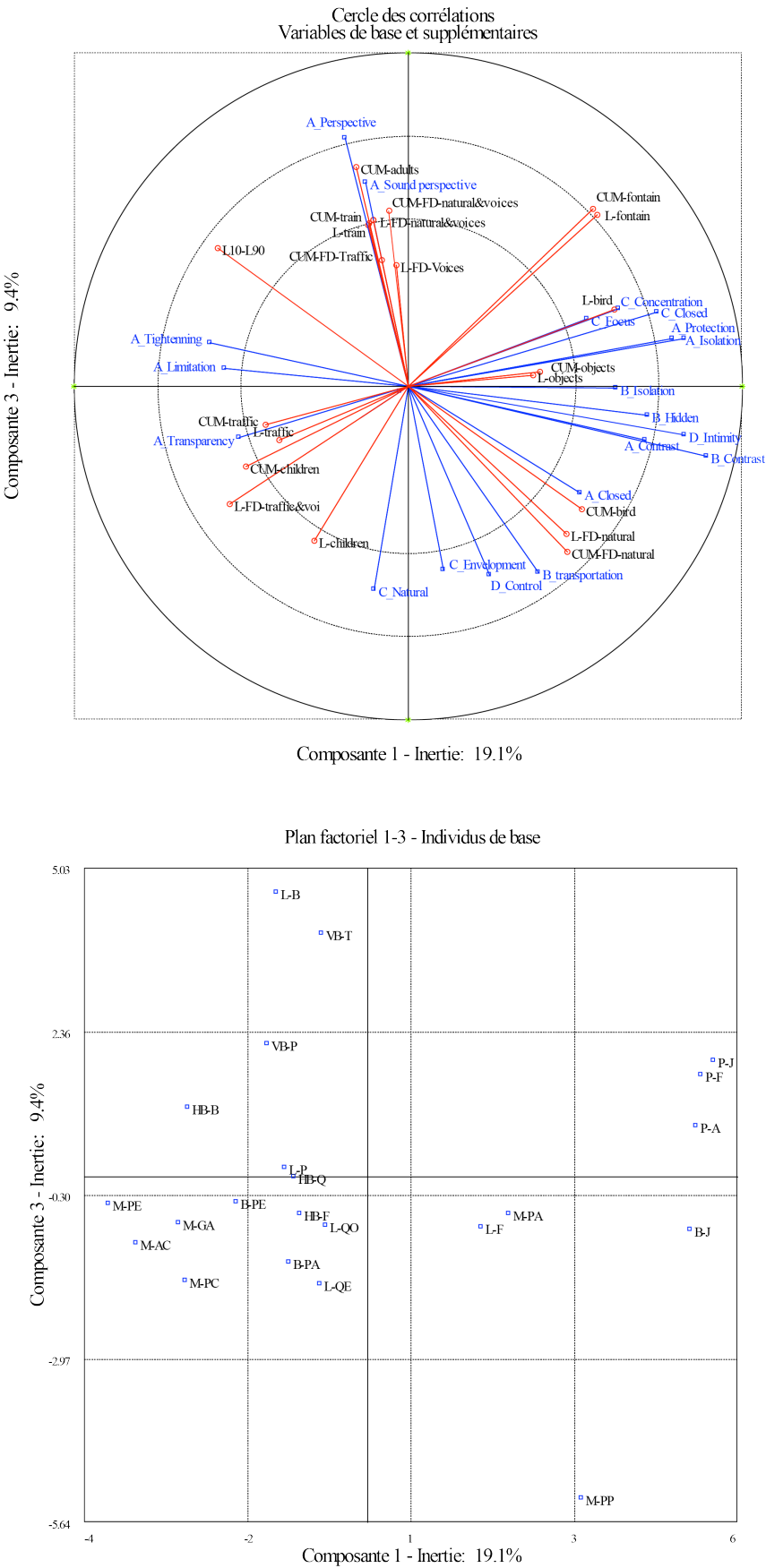
Figure 3. On top (3a) Descriptors and acoustic indicators, at the bottom (3b) position of the garden landscape sub-entities in the perceptual space on the first and third dimensions.

3.3. Linear correlations with the acoustics indicators

Projection of acoustic indicators on the ACP dimensions reveals first that axis 1, related to the protection or the vulnerability of the garden from urban sound sources, is highly correlated with urban or natural sound sources (traffic noise, birds, fountain or association with natural sounds). Except for the dynamic indicator (L10-L90), axis 1 is never correlated to global sound levels. Thus, if the duration of traffic presence and its particular level are important, they do not explain the global sound level in the garden (Figure 2).

Axis 2, related to the intimacy or the sociability in the garden, is however correlated with almost all the sound level indicators (except for Lmax and L10-L90). This axis is also highly correlated with the duration of human voice presence and its particular sound level. Thus, the global sound level in the gardens seems to be related to the human presence and especially the voices (Figure 2).

Axis 3, related to the garden aesthetic, is not correlated with any level indicator. It refers to an opposition between natural sound sources on one side (birds or combination of natural sounds) to human and urban sound sources on the other side. The very natural looking gardens, fostering feelings of envelopment, are accompanied by the presence of natural sound sources, whereas the more geometrical and mineral gardens are rather related to the human or the urban sound presence. It should be noted, that sound presence of fountains is also correlated with this axis, but opposite to the natural aspect of the gardens. This is explained by the particularity of our corpus: gardens with fountains are always very mineral, with no or few vegetation (Figure 3).

4. Conclusions

Although it could be expected that the global sound level of the garden depends to it insulation or acoustic transparency from urban sound sources, it is observed that there is no correlation that could attest it. It appears that the value of the sound level can not explain the first perceptual dimension which is the most important one. Identification of the sound sources seems to be more appropriate. However, sound level indicators make it possible to distinguish gardens according to the ratio of sociability or privacy they present. The more the voices are, the higher the sound level is. This characterizes especially the gardens which are

considered as places of sociability. Finally, correlations between axis 3 and acoustics indicators highlight the relation between natural sound sources with the envelopment effects. By putting this in the light of the garden landscaping, it appears also that those sonic qualities correspond to the more vegetated gardens.

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