TOWARDS A QUALITATIVE NOISE MAP BASED ON MEASUREMENT AND PERCEPTION, THE CASE OF ROSSIO SQUARE IN LISBON

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ABSTRACT

In the field of sound cartography, the sound maps are excellent tools as decision-making aids, in particular for noise abatement purposes. However, the acoustical space is represented by values of noise that do not distinguish the sound sources. When these values result from only one determinant noise source, contributions from other less important local sources are usually disregarded. However, on the scale of the user, the human ear distinguishes the different sound sources and the successive acoustic plans of the soundscape.

In complement to the sound maps, which cover a very broad urbanscale, a qualitative description of the soundscape is often necessary or useful for understanding people's reactions to noise. This paper presents the first results of a research by using an analytical method based on the scale of human perception in the urban space.

RESUMO

Os mapas de ruído são ferramentas de extrema utilidade na gestão urbanística e para os planos de redução de ruído. No entanto, esses mapas são diagnósticos objectivos que não contemplam aspectos de incomodidade nem de percepção do som. Nomeadamente, como representam valores globais de ruído, não distinguem influências de fontes sonoras menos importantes presentes na paisagem sonora. Ora, estas são detectáveis pelas pessoas e, eventualmente, génese de incómodo.

No presente artigo, são apresentados os resultados preliminares de um trabalho de investigação dos limites de detecção e percepção dos diferentes sons componentes de uma paisagem sonora urbana. Foi seguida uma abordagem analítica baseada na percepção humana dos sons num espaço urbano. Chega-se, então, a uma descrição qualitativa, complementar aos mapas de ruído, que se considera necessária e útil para compreender a reacção das pessoas aos diferentes ruídos presentes na paisagem sonora urbana, importante para os trabalhos de gestão urbanística e de arquitectura.

INTRODUCTION

From a qualitative point of view, the contemporary urban soundscape is an uncontrolled and unforeseeable result of noise productions. The development of tools and methods of control and composition are an urgent need in order to anticipate problems of annoyance. This was a main objective of the work reported here. Its aim is an intelligible description of the soundscape. That can be used as a decision-making tool, in the field of urban sound management and soundscape design in the area of urban design and architecture as well.

The sound maps must represent more than acoustical values. Sound shapes of designated sources must be explicit as well as they are perceived in situ. This qualitative approach can produce sound maps more usable in the practice of sound design and management.

QUALITY IN THE SOUND MAP

Let one specify, first, what one understands by quality in this paper. It is not about an aesthetic judgement of taste - on what is a «good» or a «bad» noise - obtained after consulting a segment of population. It's not either about acoustical quality such as it is given by the psychoacoustics traditional criteria. Quality is defined here as the sound attribute of an object of perception. In other words, it is when a sound or a noise produces sense to the auditor, who attributes it a name by verbalisation, that one can speak about sound quality. Perception acts by a selection of the object to be listened, by designating and isolating it of its context [1]. Quality is related to the cognitive process, which involves the user in the analysis of sound information. All things considered, quality here answers the question: what does one listen at a precise point in space and how to report it to a map?

Therefore, quality is based on pattern recognition. But, instead of resorting to a data-processing treatment of the signal by using software of recognition of forms based on artificial intelligence, the human perception of the «measuring subject» was used instead, because it is more efficient. Whereas the known software of recognition of forms requires that the sound form is emergent from background noise, human perception has this advantage of being able to detach a sound figure from its background, even when that one is immersed into the ambient noise, according to the principle of the cocktail effect [2].

The group of Acoustics of CAPS/IST has developed the noise map of Lisbon [3]. This map can not translate particular influences of local sources in areas where they can be well perceived by the users at public spaces. That is the case of *Praca do Rossio* in Lisbon. This was chosen for this work, since its soundscape is quite varied and the human occupation is always diversified.

METHOD

Sound recording

A programme of acoustical measurements was conducted. Sound samples were recorded in areas where people circulate and can listen to the urban ambient noise. The voices and other human noises as well as the inaccessible surfaces were ignored. In the area described by the fig. (2), 60 sound fragments of thirty seconds were taken at 10 metre intervals approximately. The complete sound recording was taken during one hour, between 12h00 and 13h00 at *Praça do Rossio*, in Lisbon.

Having noted the principal sound rhythms on-the-spot, like that of traffic rythmed by traffic lights, all the fragments were assured to be in phase with these rhythms. In this way, the fragments are similar in their sound composition.

Analysis technique

By listening and while paying attention (cocktail effect) on only one type of sound beforehand (traffic noise and the water fountain), a masking pink noise was gradually introduced, until the limit of audibility for the selected sound was reached. The pink noise corresponds to the measure of the designated sound [4].

A musical composition software was used to mix up each fragment with the pink noise. All fragments were measured with appropriate software.

Each sound fragment underwent two analyses, for the water fountain (fig.1) and for the traffic noise (fig.2). Horns and urban background noise were excluded. The first one was rare and not easily maskable and the second one was masked in all cases.

Results

The measured values allowed the drawing of the curves of limit of audibility for each value of masking noise in intervals of 3 dB(A) by starting on L_{masq} value. Zero value indicates that the noise is naturally inaudible *in situ* without added masking noise. Background noise proved to be sufficient in these cases. One should note, however, that the values of the curves around the represented source do not indicate its acoustic level but the level of the pink sound necessary to reach the limit of audibility.

The figure.1 shows the sound topologies [5] of the fountain at *Praça do Rossio*. The figure can show that sound from the fountain is not perceived in points close to the sidewalks.

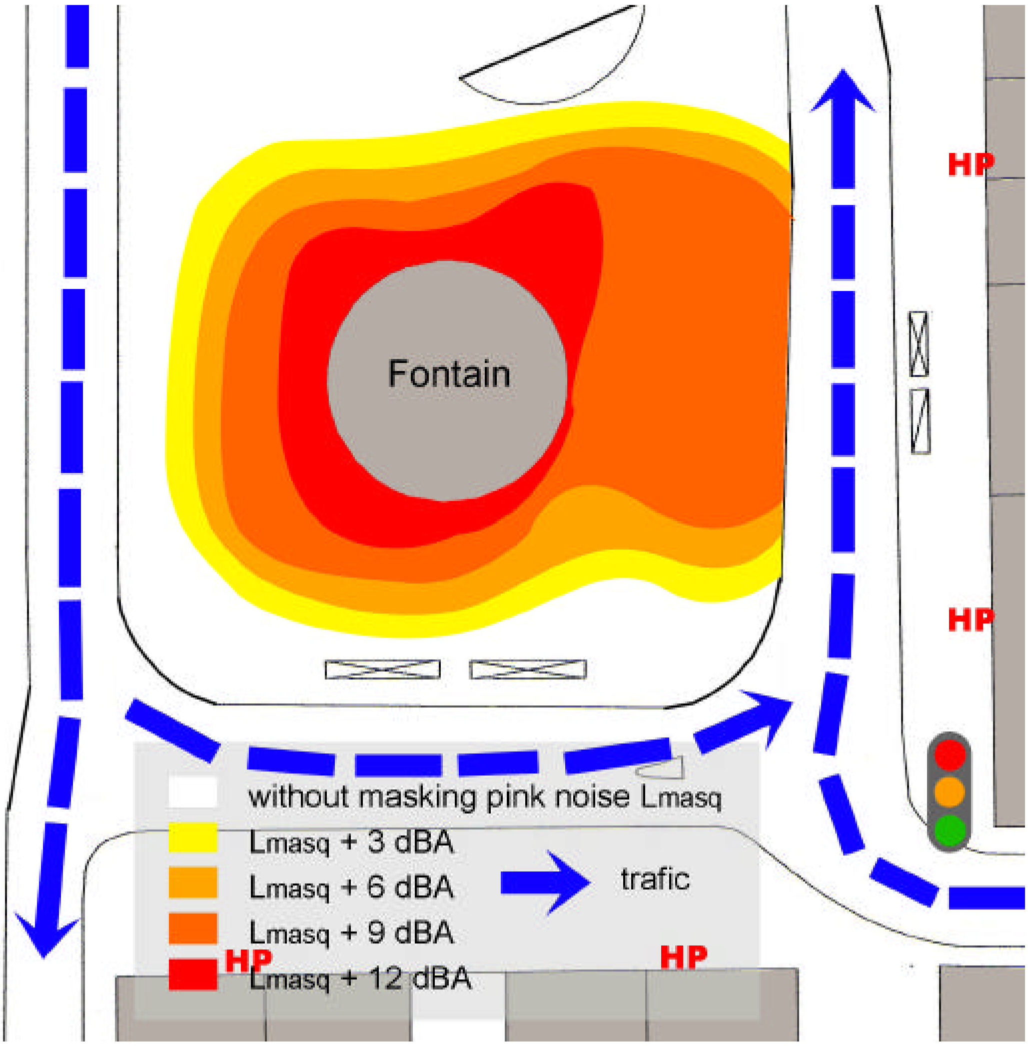

Figure1: Fountain sound topologies, Rossio square, Lisbon.

In figure.2, the sound topologies of the traffic in the square are represented.

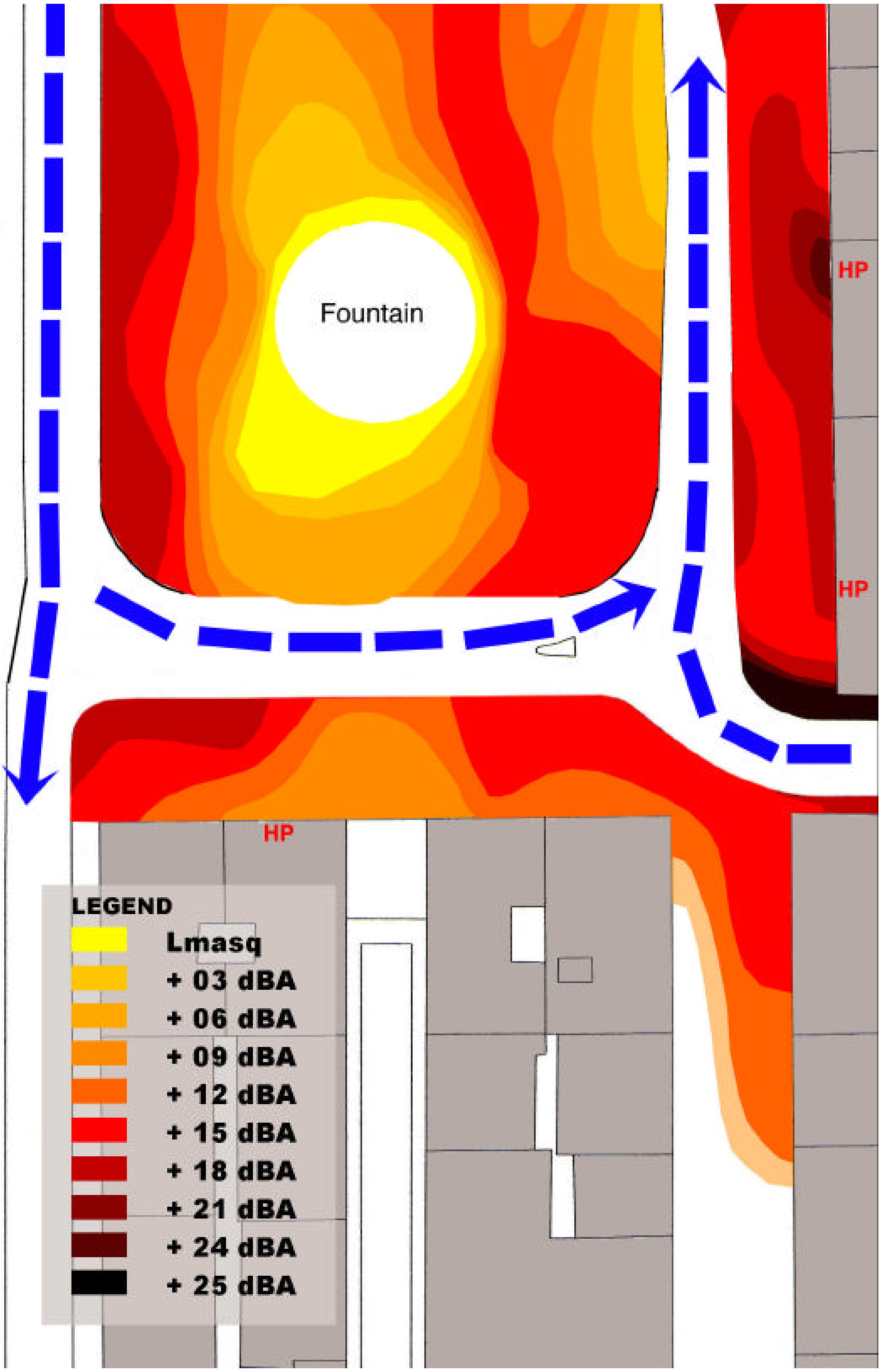

Figure 2: Traffic sound topologies, Rossio square, Lisbon.

DISCUSSION

The object designated by perception is not only noise as a signal but also the source that produces it, even if it is not totally perceptible. The sound object is an object or a set of physical noisy objects, recognised by perception and defined by language (fountain, traffic, voices, etc). Human perception is active in the way that it «reconstructs» an object as a whole based on the perception of a part.

The topology curve can represent noises of the same object (traffic noise for example) even if only one (a single car) contributed to the measured value. This method is based on the cocktail effect pushed to the limit of audibility by introducing a masking noise. Therefore, the values were obtained in borderline cases of perception. In this way, the method resembles the tests of intelligibility. It is thus important to define well the object that one wants to represent in order not to puzzle the user's perception.

This method shows the importance of language in the process of perception and measurement of a noise when one aims for a qualitative representation. In this method, the language precedes perception in contact with the signal because one must define in advance the object that one wishes to measure by asking the user to pay attention exclusively to it (traffic noise, water fountain…).

The second point of discussion regards the status of the designated object and of the sound signal which reveals it. In figure (1), each curve indicates a limit from which an object is no longer perceptible (masked by the background noise) and it also represents the contour of the sound contact with the object. That is the sound topology of that object. This sound topology is defined by the set of points having the same audibility ratio with a noisy object and which is given by the added masking noise.

The zero curve indicates the «natural» audibility limit *in situ*. Curve L_{masq}+9 dB(A) indicates the limit of audibility obtained with an increased background noise of L_{masq}+9dB(A), and so on. Each curve thus shows a limit from which occurs a qualitative rupture of the listening: beyond which the object is no longer audible and within of which the listener is in contact with the sound object.

As the background noise is fluctuating in space and in time, the sound topology of the represented object is also fluctuating. The concentric curves can be understood as moments of contraction and expansion of sound topology relative to the sound maps by variations of level of background noise by stages of 3 dB(A). Actually, the background noise has not the same acoustic spectrum as the pink noise and does not vary uniformly in all the directions of space.

CONCLUSION

The results showed that the introduction of human perception during the process of analysis and of treatment of the signal makes it possible to target measurements on one or more noise sources selected separately from their background noise. Contrary to conventional measurements, which yields overall values of LAeq, without distinguishing sources, the method presented here allows a space description of a soundscape by standing out each sound form from its context.

However, in this method the noise of each source is not measured but its limit of audibility is related to the fluctuations of the background noise. In this sense, such a qualitative representation is a good complement to the measured or calculated noise maps.

Furthermore, considering that the necessary measurement and analysis procedures are very demanding, the scale of such a map remains restricted. It can measure the range of a noisy source in a given place, test the range or the masking of an urban device (fountain) or contribute to the decision and the design of a specific architectural project, for example.

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