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The limit of audibility as a perceptive criterion for qualitative maps

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RESUMO: Os mapas sonoras quantitativos são ferramentas extraordinariamente úteis mas revelam limitações intrínsecas. Não é clara nem, muitas vezes, aparente a correlação entre os níveis sonoros mostrados nos mapas e incomodidade, por exemplo. Aqueles mapas também não apresentam informação quanto à forma como os diferentes ruídos representados nos mapas são percebidos. Torna-se, então, necessária uma apreciação qualitativa do ruído ambiente, em especial em grandes espaços urbanos.
A maioria dos estudos qualitativos relaciona o conceito da qualidade com a forma como o ruído é percebido. A percepção é considerada enquanto um campo das variáveis a explorar, enumerar, classificar, etc. Há, então, um vazio epistemológico entre a abordagem quantitativa e a qualitativa - entre o objecto de percepção e o percepiente. No presente estudo, foi adoptada uma abordagem intermediária. A percepção é utilizada enquanto técnica da medida para revelar as formas do som que compõem a paisagem sonora ou o espaço sonoro urbano.
Este artigo apresenta uma nova técnica que considera o ouvido como peça do dispositivo de medição e a percepção como uma ferramenta de processamento de informação, como um filtro semântico. O objecto da observação não é a percepção como tal mas a significância de distintas fontes sonoras componentes do ambiente acústico. Os mapas de ruído obtidos são qualitativos mas onde a qualidade é um atributo sonoro de uma fonte e não do julgamento estético do percepiente.
Neste artigo, é apresentado o método de trabalho bem como os primeiros mapas sonoros qualitativos da Praça do Rossio, em Lisboa. São discutidos os resultados e a sua aplicação.

ABSTRACT: Quantitative sound maps are extraordinarily useful tools but have shown limitations. It is generally agreed that there is a lack of information concerning the way in which the different noises represented in the maps are perceived. This calls for a qualitative assessement.
However, the majority of the qualitative studies are related to the concept of quality as the way in which (how) the noise is perceived. Perception is regarded as a field of variables to explore, enumerate, classify, etc. There is then an epistemological gap between the quantitative and the qualitative approach: the one between the object and the subject. However, there is an intermediate approach that was followed in our study. Sound perception by the individual is used as a measurement technique to reveal the sound forms that compose the soundscape or the urban sound space.
This paper shows that it is enough to consider the ear as part of the measurement device and perception as an information processing tool by semantic filtering. The object of observation is no longer perception but meaningful sound sources, revealed in extreme cases of their audibility. The sound chart obtained is qualitative but here quality is the sound attribute of a source and not the aesthetic judgment of perceiver.
In this paper, the method is presented and the first qualitative sound maps of Rossio square in Lisbon are shown. The results and their use are discussed.

1. INTRODUTION

The visual representation of the sound phenomena, although paradoxical from the sensitive point of view (to make visible what is audible), saw a significant development in recent years both in technical and practical terms. This was both used and pushed by the legal framework both at the European and at nation level. Indeed, the quality of the sound environment is a very keen demand for the benefit of the citizens.

However, the current quantitative sound maps describe an image far from the real soundscape composition. There is an undeniable difference between the graphical representation of the environment and the way it is really perceived.

This justifies the demand for a qualitative representation of the sound environment. However, if the request for qualitative charts is quite real, the criteria of quality remain somewhat undefined.

2. ABOUT “QUALITATIVITY”

2.1 The gap between quantitative and qualitative approaches

If quality is a term that emanates initially from the inhabitants, the majority of the qualitative studies return to a representative panel of users the care to define what is of quality and what is not. "Quality" is considered to be subjective. It is in fact a criterion of judgment of taste. But the ordinary judgments change not only from one person to another but also from one situation to another for the same user. Then, temptation to quantify by the number what is qualified by the language is useless: because the field of representations is discontinuous and does not obey the geometrical logic of continuity. The debate is quite old.

One can express in terms of language the significant forms described by the inhabitants. In this case, one explores the field of the variables of the representations and perceptions and in certain cases of the behavior of the inhabitants as a culture of “savoir-faire” [1]. But then, any plane representation, if it were possible, would be a reduction: being centered on the individual and his representations, we doubt extremely that a space projection is possible.

In the fields of acoustics, namely of psychoacoustics, the criterion of quality focuses on the signal. They have the merit to make obvious some qualities that are perceptible even if the scale is that of the signal. These qualities are not operational on the scale of the representation of the urban sound phenomena. These psychoacoustic criteria cannot help to separate the sound sources of the environment.

Let one retain that what separates these two antagonistic approaches is initially the scale of observation in each field, that of the signal versus that of the subject or the social group. Technically, one opposes the sensitivity of the measuring device to the sensitivity of the subject.

However it is possible to reconcile both approaches if one introduces a subject into a measurement technique protocol. The object observed becomes the surface on which occurs the sound phenomenon. The sensitivity of the materiel joining that of the subject to account for the semantic space forms of an urban sound phenomenon.

In a former paper one tried to specify what is meant by "quality"[2]. "Quality" was defined as the sound attribute of a listened and recognized object. Quality refers to the part of acoustic information that allows a subject to recognize a sound and to differentiate it from another one, regarding to the well known cocktail effect [3]. Thereby, quality could remain a sound value shared by all perceivers and still attached to the geometrical extent where it occurs.
This definition will be kept, but one will adopt preferably the concept of qualitativeness. The criteria of qualitativeness are those that allow one to differentiate sounds (cocktail effect). It will be shown that these criteria can provide a space representation of differentiated sources of the sound environment in a similar fashion as they are perceived *in situ*. Perception has the property to be common to all perceiving subjects because it is regarded as a process of contact and not a field of variables to be explored.

2.2 Perception as a link between the objective and the subjective fields

An alternative approach of research which takes into account the listener's perception was followed. This technique is not opposed to the traditional approaches. This method regards sound perception as a bond between the objective data of the environment (the located signal) and the subjective data of listening (cognition, social representations). Introduced into the process of measuring, perception becomes a good semantic filter, which is not yet replaced by the traditional instrumentation. The recognition of forms is achieved in a natural way without using specific software. The qualitative representation of an urban sound space can thus be based on this type of filtering to distinguish between the different component sound sources. However, a question arises: how to report on a plan a differentiation obtained on only one point of listening?

2.3 Audibility as a qualitative criterion for sound maps

Since the representation of a sound phenomenon is based on a localized sound and space variable, it is then enough to vary the points of listening in order to cover the entire surface which one wants to represent. But in order to obtain simultaneous results, it is recommended to carry out samples of fragments, which will be analyzed by listening a posteriori. The points where a source is audible at the same time represent the acoustic field where it is diffused. Beyond these points it is not still audible. Therefore, if the qualitative representation of sound space consists in separating the sources from the whole environment, then the limit of audibility is a qualitative criterion.

2.4 Sound topologies

In fact, the points where a source is audible correspond to the sound topology of this source. The curve that represents its limit of audibility is the limit of contact with this source [4]. The concept of topology applies legitimately to sound space to distinguish sources as well as visuo-tactile topologies distinguish tangible objects. Let one specify that a sound topology is not a material object producing a sound. It has its own wrap where its own sound is diffused inside and beyond which it is not audible any more. Also let one specify that sound topologies

are not static in space. They are in perpetual movement depending of the fluctuations of their own acoustic energy, but also of the fluctuations of the background noise. Moreover, the background noise is partially masking the sound topology inside it and totally masking it beyond its limits.

2.5 The masking effect as a simulation of background sound variations

In order to obtain an outline of the fluctuations of sound topologies, one can gradually introduce a masking pink noise together with each sound fragment. The levels of the masking signal deferred on the chart allow, by interpolation, to draw the curves of fluctuation of sound topology. That is equivalent to an increase in the background noise, which is a permanent natural mask.

2.6 The language directing the measurements

Usually, one takes into account the inhabitant perception of the noise and the way they qualify the surrounding sounds. The majority of these approaches start first by measurement or computation, and then validate those objective results with some user's perceptions. The language is said to be an access to the human field of perception and collective representations. The reactions of these users are given as qualitative results that identify the components in a complex phenomenon. But the complexity here only concerns the field of perceptions and representations expressed by the language. The process is:

Signal → Perception → Language

If the aim is a qualitative spatial representation, then an inverse process can be followed. Meaningful sounds of the environment that can be defined by the language are identified and selected beforehand. In this work, traffic noise, water sounds and ambient music were selected. They were the major sources in the urban area under analysis. Then, by an active perception procedure (cocktail effect) one can explore the environmental area and look for the signal corresponding to the defined sound. This is possible by an inversion of the classical process described below:

Language → Perception → Signal

3. RESULTS

3.1 One source maps

The first map was obtained by focusing on the traffic noise when listening to the samples. The masking pink noise was not needed in the walking street because the traffic noise was already masked by the human activities an ambient music. The fountain was intensely masked in its surroundings.
Figure 1 shows the topology of traffic noise at Rossio square.

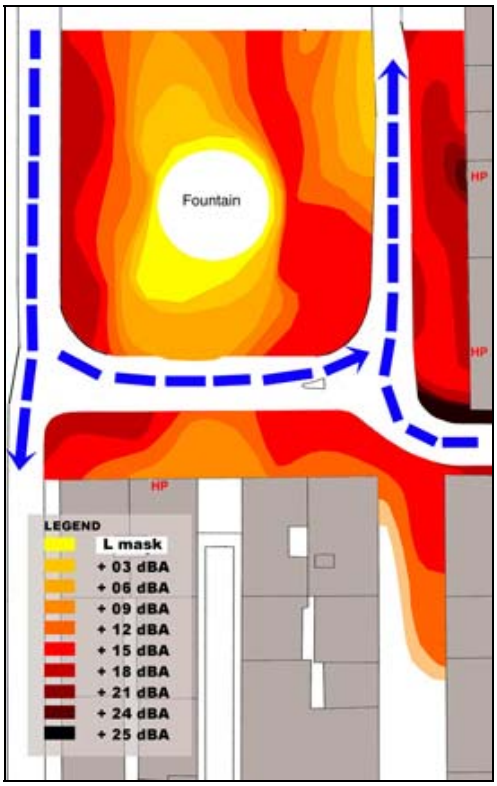

Figure 1 – *Traffic sound topologies in Rossio Square in Lisbon*

The electroacoustical ambient music diffused at Rossio Square is generally heard in the walking areas, see Figure 2.

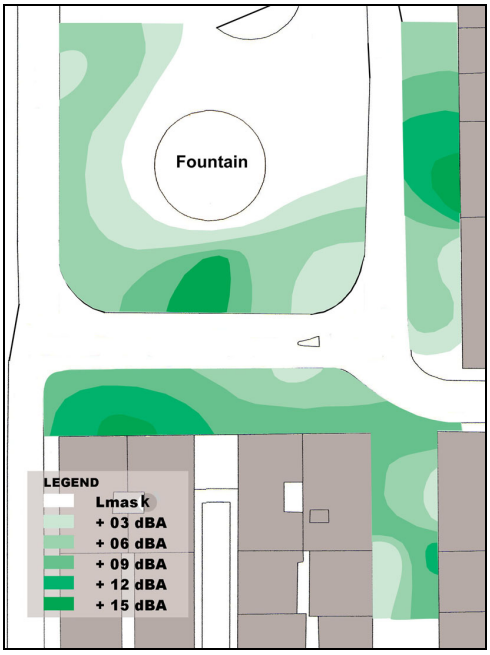

Figure 2 – *Ambient music sound topologies in Rossio Square in Lisbon*

The sound of the fountain is not heard in the lateral sidewalks, as shown in Figure 3. Traffic noise is dominant, and a masking sound source.

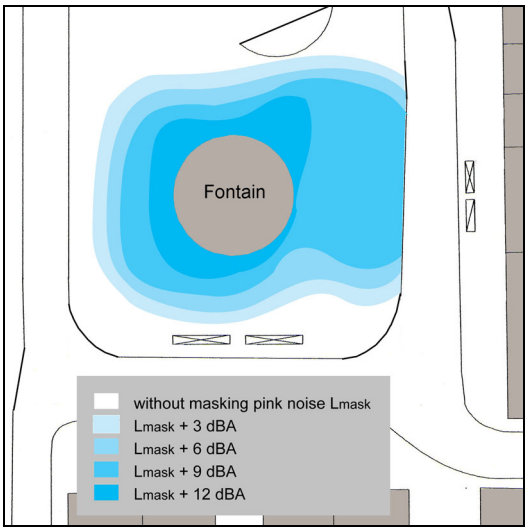

Figure 3 - *Fountain sound topologies in Rossio Square in Lisbon*

3.2 Dominant sources map

By a combination of the previous three maps, one can draw a map of the dominant sources. Dominant sources refer here to the masked sources, not to their acoustic level. This map of intelligibility makes obvious the distribution of the sources in the square. The difference with an equivalent calculated map is that the masking effect between the sources is taken into account with this method.

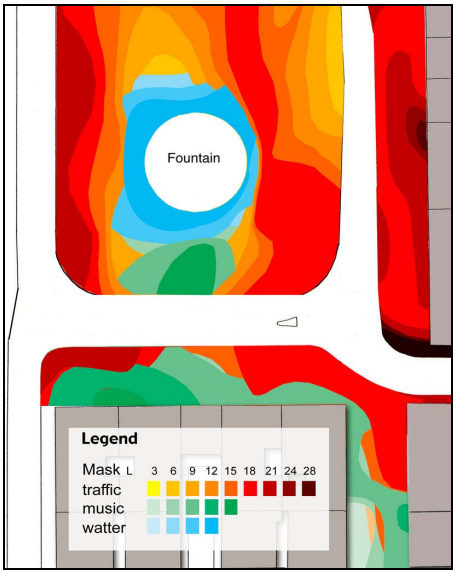

Figure 4 – *Dominant sound topologies in Rossio Square in Lisbon*

3.3 Soundscape representation of a potential walk course

Starting from localised information, one can describe the composition of the soundscape that is potentially heard by some walkers, see Figure 5. In this way, one can observe with more acuity the critical points on the plan where annoying or dominant sources are active (point 7). One can also see where this dominant noise becomes masked (point 17. for example).

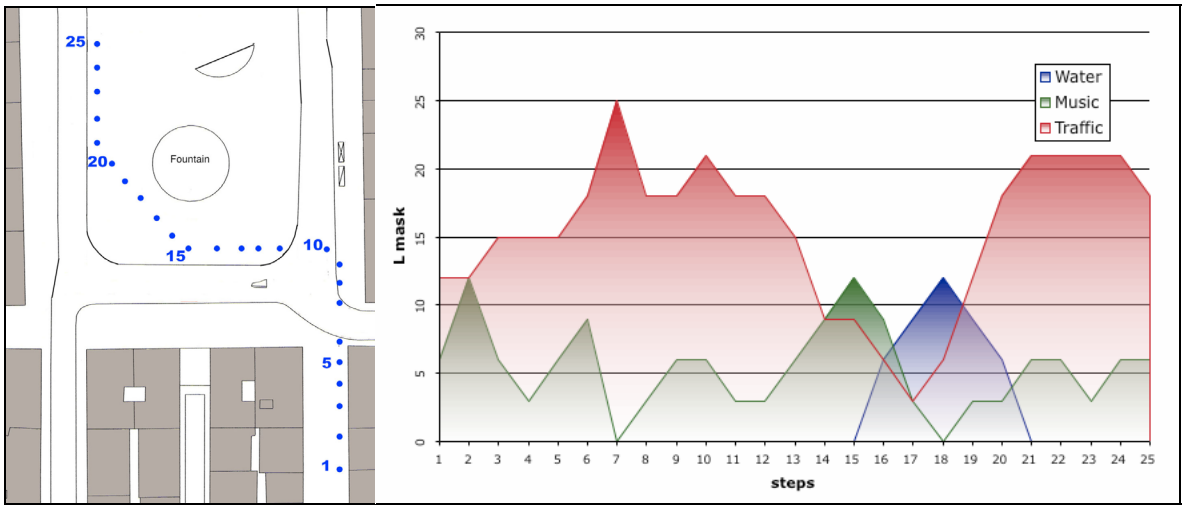

Figure 5 – *Soundscape composition for a potential walk course in Rossio Square*

4 CONCLUSION

The results showed that the introduction of human perception in the process of analysis and of treatment of the environmental acoustical signal makes it possible to target measurements on one or more noise sources selected separately from their background noise. Contrary to conventional measurements, which yield overall values of L_{Aeq}, without distinguishing component sound sources, the method presented here allows a space description of a soundscape by standing out each sound shape from its context. It can measure the range of each different component noise 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.

One believes that the spatial qualitative sound map can target with more precision any action on the urban sound environment. These are required to regulate a problem of annoyance, or management and compose of the soundscape scenarios or control of its evolution in the short and in the long term.

One hopes that a higher precision in the visual representation of the sound makes the action on the urban sound environment more efficient both in terms of the results to be achieved and of the cost-benefit ratios of the possible solutions.

A new technique that leads to the production of qualitative sound maps has been presented and discussed.

Qualitative noise maps can be powerful tools for the urban technicians and architects working with noise in urban areas, since they provide information on how the citizens perceive the urban soundscape.

ACKNOWLEDGEMENT

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