ACOUSTIC CHARACTERISATION OF HISTORICAL SQUARES: A CASE STUDY

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Abstract

Every pleasant place has its own sound. Unfortunately the noise produced by human activities may cover these sounds and consequently destroy their identity. The present work aims to characterise the acoustical environment of one of the most famous historical squares in Catania (Sicily) where sound-marks and traffic noise live together. By means of an extensive measurement campaign it was possible to characterise each source, to asses the relative weight of each sound component in order to emphasize or control them. A map containing the areas of influence of each noise source was produced, and interviews to citizens living the square were carried out. This allowed the definition of a strategy to improve the quality of sound perception in the square. The proposed method might be extended to other squares containing sounds to be preserved.

INTRODUCTION

The main goal of the present work is to describe a methodology to characterise the acoustic environment of historical squares with an application to the Cathedral Square of Catania (Italy) [1].

The main steps of the procedure are:

- **Acquiring a deep knowledge of the urban relevance of the square, with reference to its architecture, value, its social and official role;** by means of an analysis of traditional instruments like urban plans and traffic plans as well as direct experiences revealing "point of attraction" in the square, one can understand how the square lives and is lived by citizens;
- **Carrying out a "sound investigation" of the square, in order to distinguish**

several sound sources with different characteristics; by means of sound-walks and bi-aural recordings, it is possible to recognise the most frequent and typical sound sources as well as the less frequent but anyway important ones in order to guide the further steps of the investigation;

- **An objective analysis of the noise climate of the square;** by means of a deep measurement campaign it is possible to identify, for each sound source, the directions with the highest sound pressure level, the different sound emission in specific directions (0°, 45°, 90°), the divergence of the sound versus the distance and the objective influence of each sound source on the global acoustic environment. The main result of this step is the **acoustic map,** which includes "areas of objective dominance"(where a specific sound source prevails over the others); "mixed areas" (where two or more sound sources influence significantly the noise climate of the square); "neutral areas" (where specific sound sources are not distinguished). Further, the collected results will orient the next step;
- **A subjective acoustic analysis;** by means of interviews to a significant number of citizens it is possible to obtain useful information about the real perception of each specific sound source occurring in the square; for several reasons (historical, social, cultural, etc.) the collected outcomes can give results significantly different from those obtained by the measurement campaign. The main result of this step is the **sonorous map** where three different areas are identified: "areas of subjective dominance"(where one can easily distinguish only one specific sound source and rarely other sounds); "mixed areas" (where one can distinguish two or more comparable intensity sound sources); "neutral areas" (where one can not distinguish a specific sound source).

THE CASE STUDY

The Cathedral Square of Catania (Sicily) is a baroque square re-built after the catastrophic earthquake in 1693. It has a very regular shape (62m x 64m) and it is encircled by same age buildings, with an average fifteen metres height. At the centre of the square there is the symbol of Catania, a middle-age sculpture of an Elephant that is placed on the top of a fountain, called "Fontana dell'Elefante". On the south side of the square there is another important baroque fountain called "Fontana dell'Amenano", from the name of the river that slides under it (Fig.1).

The square is a pedestrian area except for the north side border that is crossed by vehicles. Due to the historical and social importance of the site as well as the large number of public offices located there (the Town Hall, among others), human activities throughout the square are very intense.

Sound Investigation

Sound-walks along the main crossing paths were done in order to identify all the perceptible sound sources [2-4]. As one can imagine such an experience is very complex due the variety (in number, intensity and types) of the sound experiences inside a square. In addition a 24h bi-aural recording was made at the centre of the

square and post-analysed in order to assess the main sounds and noise of the square (Fig.2).

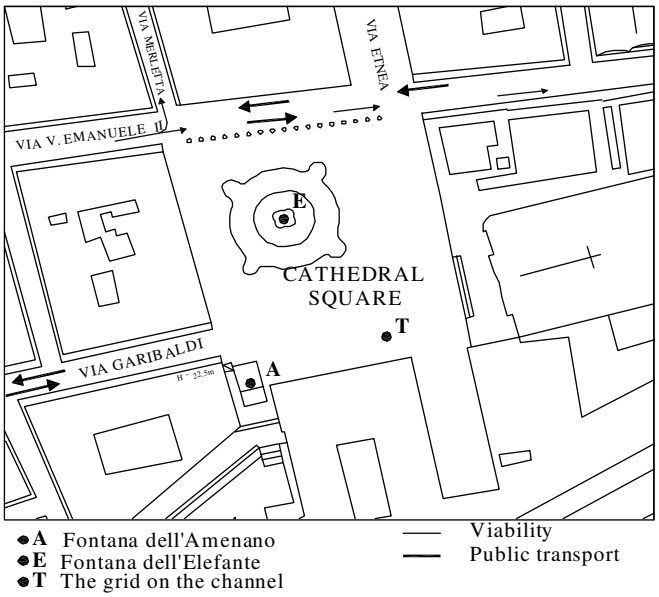

Figure 1 – Cathedral Square of Catania

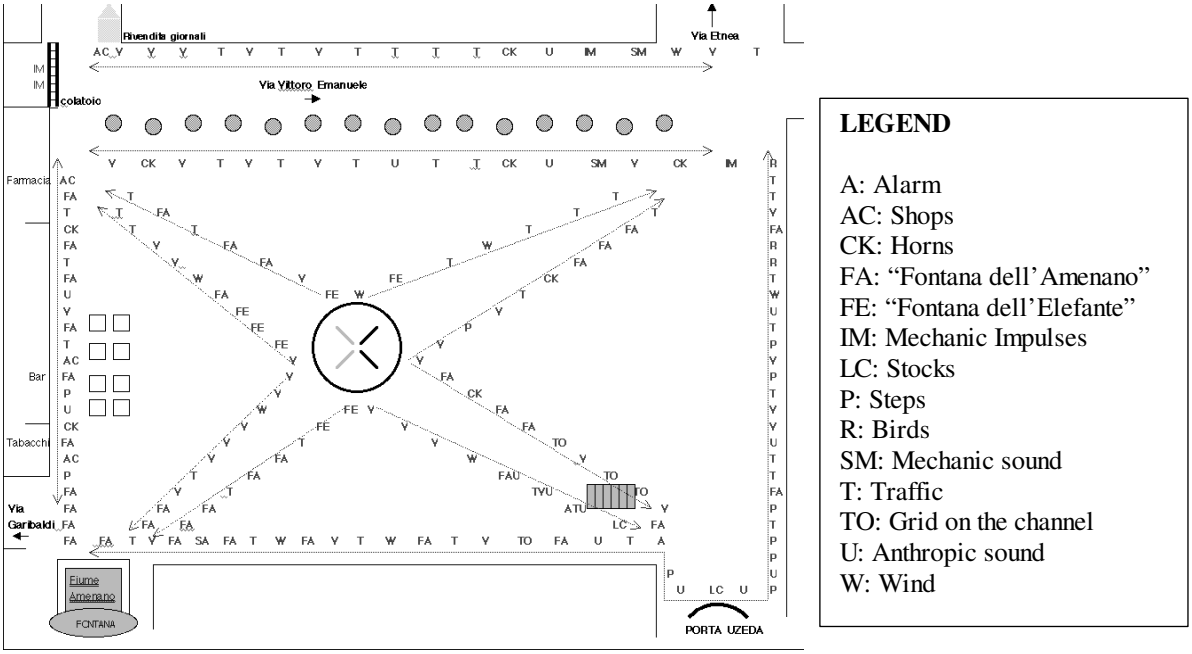

Figure 2 – Sound-walks along the main crossing path

At the end of this step, five main sound/noise were identified as typical of the acoustic of the square. They are (see Fig.1):

- The "Fontana dell'Amenano" (A);
- The "Fontana dell'Elefante" (E);
- The grid on the underground channel (T);
- The traffic noise;

- The anthropic noise

In the present study only the fist three stationary sounds will be analysed; the last two ones will be discussed in future papers.

Objective analysis

Starting from the sound sources listed above, a number of measurements was carried out, such as:

- The equivalent sound pressure level ($L_A$eq) on the perimeter of the sound source;
- The equivalent sound pressure level ($L_A$eq) on the main axis, doubling the distance (1m, 2m, 4m, 8m, 16m, 32m);
- The 90% percentile level (L_{90}) on the main axis, doubling the distance (1m, 2m, 4m, 8m, 16m, 32m).

All the measurements were done during the night in order to minimize the effect of traffic noise; different integration times were chosen for each sound source. The microphone was placed at 1.5m from the ground.

The "Fontana dell'Amenano"

The "Fontana dell'Amenano" (Fig.3, left) "sounds" even if it doesn't work. In fact, due to the river that slides under it, a typical sound is always emitted. As one can see in Figure 3 (right) the spectrum measured in two points (point 1 and B in Fig.4) at one metre distance has one peak at 63Hz and another one around 1kHz. When the fountain is turned on (7am; 22pm), and consequently the water falls from the top, the sound level increases, especially at high frequencies and the peak is reached at 4kHz.

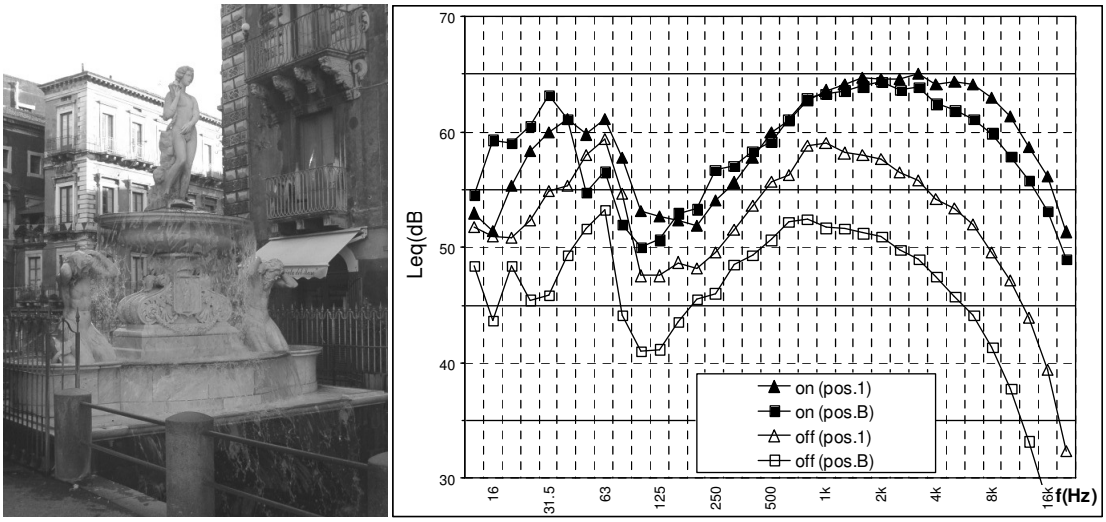

Figure 3 – The "Fontana dell'Amenano" (left) and its spectrum at one metre distance (right)

Further, the fountain has its maximum emission along the longitudinal axis when it is turned off, while it emits more uniformly when is turned on (Table 1). The

reason of this different behaviour is probably given by the origin of the main sound: when the fountain is off, the main sound source is located at the outlet of the river under the fountain (point 1 in Fig.4) while, when it is on, the sound is mostly due to the water fall (point B in Fig.4).

By comparing $L_A$eq and L_{90}, as reported in Figure 4, one might conclude that the sound of the fountain is dominant within a distance of 8metres from it; over this distance also other sounds give significant contributions to the global noise climate of the square.

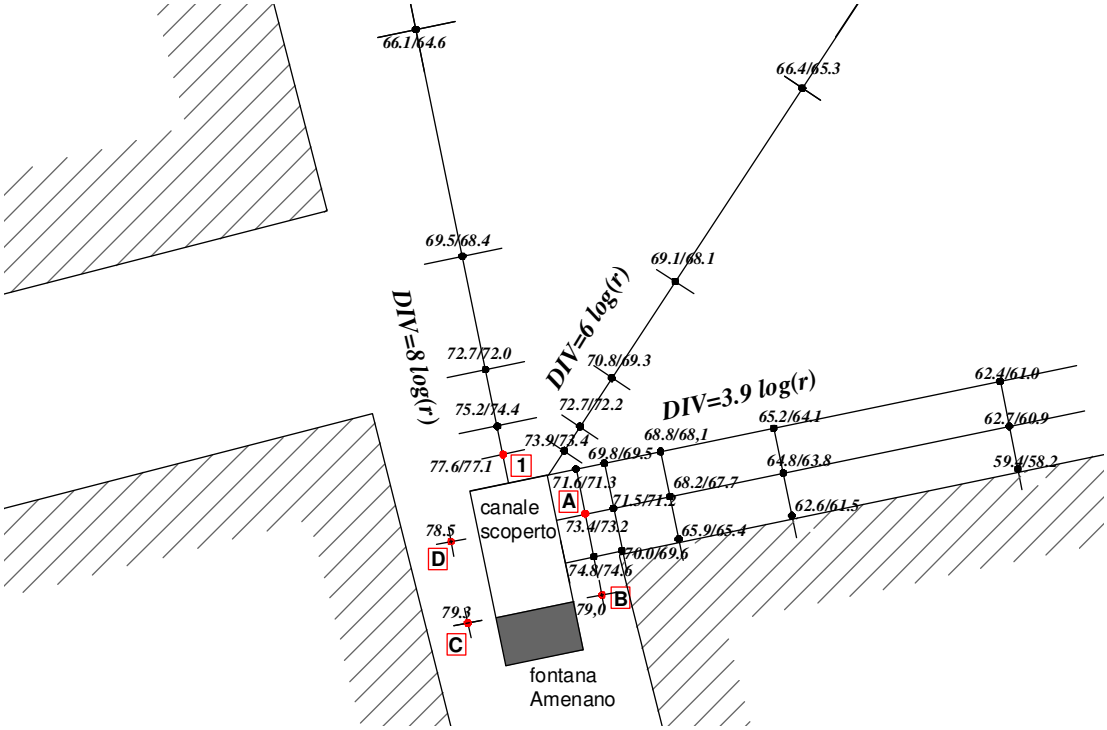

Figure 4 – Equivalent sound pressure level ($L_A$eq), 90% percentile level (L_{90}) and divergence of the "Fontana dell'Amenano"

Table 1 – Equivalent sound pressure level ($L_A$eq) and 90% percentile level (L_{90}) in dB(A) at one metre distance along the perimeter of the "Fontana dell'Amenano"

Point (see picture 4)	**Fountain off Leq(A)/L_{90}**	**Fountain on Leq(A)/L_{90}**
A	67.0/66.7	77.9/77.4
B	63.6/63.2	**79.0 (fall)/78.5**
C	63.9/63.6	**79.3 (fall)/78.7**
D	67.8/67.5	78.5/77.9
1	**70.0 (outlet)/69.7**	77.6/77.1

The "Fontana dell'Elefante"

The "Fontana dell'Elefante" (Fig.5, left) has a weak acoustical emission due to the dripping water on the marble washbowl. Only at very short distance from it one can perceive its characteristic sound.

Figure 5 (right) shows the sound spectrum measured at one metre from the source, while in Table 2 (left) the equivalent sound pressure level ($L_A$eq), the minimum value (Lmin) and the 90% percentile level (L_{90}) are reported. Due to the very low intensity of the source, the last two parameters, in the opinion of the authors, seem more adequate to characterise it; the equivalent sound pressure level is much more variable especially on the side of the fountain facing the road (north).

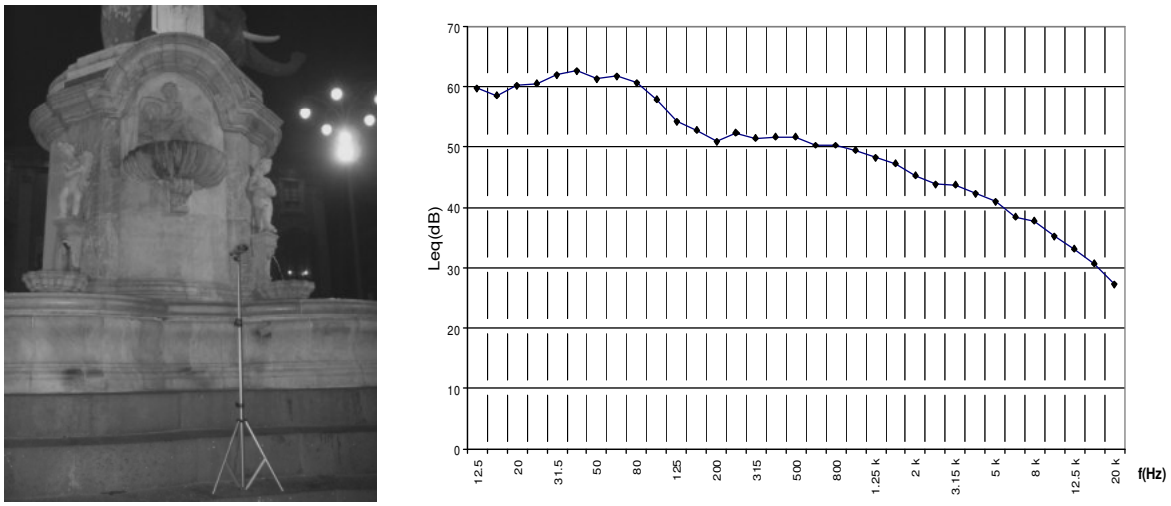

Figura 5 – The "Fontana dell'Elefante" (left) and the spectrum at 1metre distance(right)

The grid on the underground channel

The river "Amenano" slides also under a grid (Fig.6, left) placed in the south-east part of the square (see "T" in Fig.1) producing a characteristic sound whose spectrum, measured at 1metre distance, is shown in Figure 6 (right).

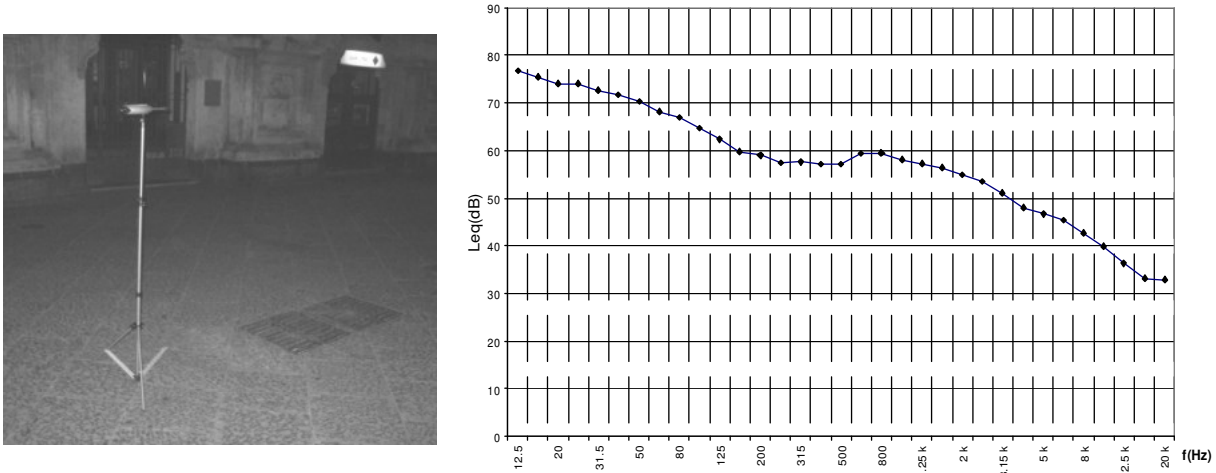

Figure 6 – The grid on the channel (left) and the spectrum at 1metre distance(right)

The comparison between $L_A$eq and L_{90} (Table 2, right) seems to demonstrate the dominance of this sound for short distances. Further, the measures all around the grid are similar: the grid behaves like a hemispherical source.

Table 2 – Equivalent, 90% percentil (L_{90}) and minimum sound pressure level in dB(A) at 1m from the "Fontana dell'Elefante" (left) and at 1m from the grid (right)

Point at 1m	**Fontana Elefante Leq(A)/L_{90}/Lmin**
South	58.7/56.5/56.0
North	62.0/55.5/53.9

Point at 1m	**The grid on the channel Leq(A)/L_{90}**
South	66.9/66.4
North	66.9/65.5

Acoustic map

The data collected in the objective analysis can be express by means of an acoustical map (Fig.7, left) in which areas characterized by different sound pressure levels are represented in different colours (or grey scale). By means of such a map it is possible to understand how the sound/noise is distributed on the square but it is impossible to evaluate the contribution of each sound source in the global sound climate except for the areas within 8 metres from the "fontana dell'Amenano" and within 4 metres from the grid; for these areas, one can only assume a dominance of those sound sources. In this map the sound of the "Fontana dell'Elefante" "disappears" being masked by lauder sounds. Nevertheless this map was very useful to orient the subjective analysis in order to better understand the perceived influence of each sound source on the global noise climate.

Subjective analysis

By means of interviews, a significant number of citizen (100 people) between fifteen and forty-five years old were asked to evaluate and compare the intensity of each sound source to the others. As a result a sonorous map was plotted (Fig.7, right), and further information about distribution and perception of the sound was obtained.

Sonorous map

In this map the areas of dominance appear to be larger than those in the acoustic map; due to the continuous emission of these sound sources, they are probably better identified by the citizen and consequently perceived as more intensive.

The "Fontana dell'Amenano" is dominant over 12 metres and its intensity is still considered equivalent to that of the traffic sound for further 20metres in length. Furthermore, on the opposite side of the square (east), its sound still gives a relevant contribution to the global sound climate.

Concerning the sound of the river under the grid, it is dominant over 4 metres distance and still relevant at ten metres.

The sound of the "fontana dell'Elefante", even if weak and masked by that of the "fontana dell'Amenano" and by traffic sound, is considered by the citizen relevant within 3 metres distance.

In addition, the "natural sound" of the water is largely accepted and regarded as "pleasant" even if it is very intensive (over 77dB(A) in the case of the "Fontana dell'Amenano"). But this favourable impression is strictly related to the symbolic role of the sound source; in fact, while more then 80% of the interviewed people consider "pleasant" the sound of the "Fontana dell'Amenano" and "Fontana dell'Elefante", this percentage decreases to 40% in the case of the river under the grid.

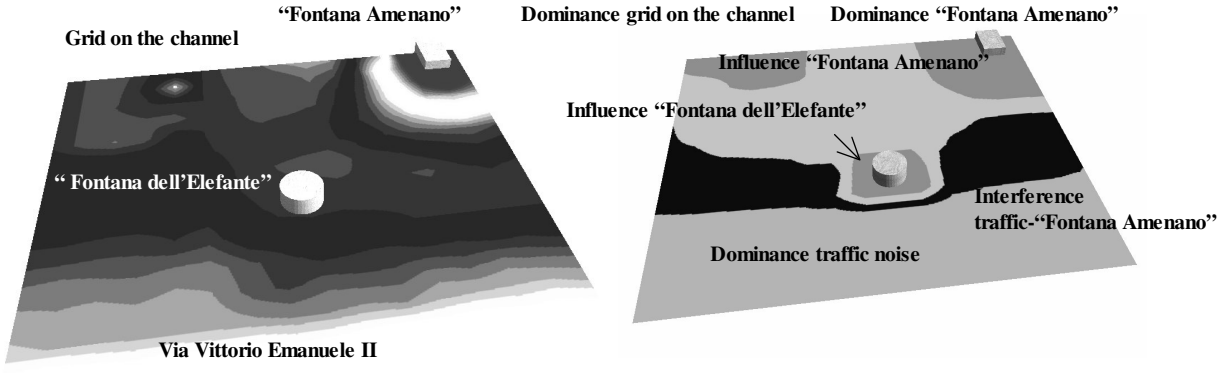

Figure 7 – Acoustic map (left) and Sonorous map (right) of the Cathedral Square

CONCLUSIONS

In order to protect and emphasise the characteristic sound-marks of a public square it is necessary to join together the objective data and the subjective experiences. The objective analysis, by means of an extensive measurement campaign focused on the main sound source, can guide a deeper and specific subjective analysis whose main result is a sonorous map. This map is a faithful expression of the "real sound" perceived in a square.

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