euronoise
Naples 2003

paper ID: 250 /p.1

Soundscape Perception in Cagliari, Italy

F. Arras[a], G. Massacci[a] and P. Pittaluga[b]

[a] *DIGITA – Department of Geoengineering and Environmental Technologies, University of Cagliari, Piazza d'Armi, 09123 Cagliari, Italy, massacci@unica.it*
[b] *DIT – Department of Territorial Engineering, University of Cagliari, Italy*

Abstract: In order to study how acoustic and visual stimuli can influence the perception of the landscape, six Soundscapes and six corresponding Visual Landscapes typical of Cagliari, the capital city of Sardinia, have been selected and characterized through a binaural phonometric sampling and a photographic survey. All 36 possible combinations were submitted to a panel of 107 subjects. The evaluations expressed for the audio/visual associations highlighted how the combination of two different sensorial stimuli gives a wider basis of judgment to the interviewed subjects. The correspondence analysis, through the recognition of common perceptive patterns in the acoustic sensitivity of the local citizens, showed how the sound, more than the image, was the predominant element in the construction of their judgments. The analysis, moreover, singled out some decision parameters in the pleasantness assigned, discriminating the natural environments from the urban ones; the Hi-fi landscapes from the Lo-fi ones; the hi-Leq events from the low-Leq ones. This method suggests some requisites for drawing up an Acoustic Improvement Plan or land planning measures in general that involves the perceptive dimension of the community, particularly the auditory one, in the organization of space.

1. INTRODUCTION

One of the hypotheses that should form the basis of research-work on the effects of environmental noise, as well as in acoustic planning, is that the positive or negative effect on a subject when exposed to an acoustic field can be of a subjective nature and depends on several social factors. Such factors include: the meaning that noise assumes for the subject (and, generally, for the whole community), the subjective perception with regard to the possibility of controlling it, the general attitude towards the source and its evocative significance [1]. In fact, our ear is modelled by a sound culture that influences both the production and the collective representation of the soundscape, determining the making of an *Acoustic Community* [2]. For this reason, if the technical bases of a Plan are restricted simply to elements of a quantitative type (for instance acoustic mapping of the landscape), this would result in a discrepancy between the spatial images that the inhabitants formed in relationship to their landscape and those produced by the technical knowledge traditionally used to represent the plan. When the image with which the plan is represented does not contain elements that derive from the perceptive worlds of a society (the audible world included), it could often happen that the results of the planning are not effective nor shared [3]. The identification of the specific contribution of acoustic and visual stimuli in the evaluation of the landscape was the object of a psychoacoustic experiment carried out in Madrid [4]; the six images used in that test were devoid of any geographical identification, and the relative audio tracks originated from a database of pre-recorded sounds. In the experiment undertaken here the investigation has been contextualised, analysing some expressive soundscapes of the city of Cagliari and trying to identify possible common perceptive patterns in the sensitivity of its inhabitants.

2. MATERIALS AND METHODS

2.1 Selection of characteristic landscapes of Cagliari

In order to identify six landscapes which could be representative of places of importance for the local community, not only physically, but also in a cultural, sensitive, and evocative way, signifying the lifestyle of the inhabitants, a questionnaire was proposed with a choice of landscapes, by telephone, to a sample of 200 of Cagliari's residents. The test led to the selection of the following six landscapes: Poetto Beach (the most important beach of the main town); Via Roma (one of the main roads of social meeting); Saint Remy Bastion (a famous large square in the historic centre); Monte Urpinu (the largest urban park); Marina Piccola Wharf (a picturesque tourist dock); the Cathedral (one of the main historical monuments).

2.2 Acoustic sampling and *binauralisation*

In a second phase an *in situ* acoustic sampling was performed, for the purpose of reproducing the recorded signals for a sample of listeners, in high fidelity conditions and in accordance with the typical characteristics of the human auditory apparatus. For this reason, microphone types qualified for Hi-Fi reproduction (A.K.G.) were employed, with the following characteristics: high sensitivity, good frequency response, cardioid polar pattern. A system of two microphones was used, guaranteeing the correct reproduction of auditory perception in a process that is defined as *binauralisation*. The binauralisation, simulating the functionalities of the human auditory apparatus, allows the reproduction of the listener's psychoacoustic perception, including reverberation, single echoes, frequency colouring, spatial impression, and maintains the sensation of three-dimensionality of the acoustic event considerably [5].

The microphones had been positioned inside a polystyrene dummy-head (Figure 1), whose function is to sustain and to correctly direct the tools of reception, preventing the acoustic signals intercepted by the right pavilion to influence the left one (and vice versa), to reproduce the same conditions of diffraction, screening, reflection and absorption of the noise that the head of a

Figure 1. *Front, side and top of the binaural dummy head.*

listener would have implicated in sampling position [6]. The microphones had been connected to a Sony D.A.T. A reference signal emitted by a B&K 4321 calibrator was recorded to ensure that the reproduction volume of the sound was identical to the original one. The recorded data were then post-processed using a LD 3200 real time spectrum analyser in order to obtain the temporal course of the survey, the sound spectrum in 1/3-octave bands and the main acoustic characteristics of the samples.

2.3 Psychoacoustic test

In addition to the six selected landscapes, two audio/visual control stimuli have been included (the famous painting *The Scream* of E. Munch; a passage of dodecaphonic music; the sound and the image of a stream). These served to provoke *a priori* very unpleasant and very pleasant responses by the listeners, and to facilitate the interpretation of the output data.

107 university students from Cagliari, aged between 21 and 30 (45 men and 62 women), were interviewed and invited, first, to listen to the eight soundscapes, then to view the eight landscapes, and finally to listen to/view the 38 combinations of sound and visual stimuli (36 combinations + 2 control stimuli). The subjects were requested to score each sound, each image and each combination, by a degree of pleasure perceived with a numerical scale from 1 to 5. Moreover, they had to locate the characteristic sounds, to recognize the soundscapes and to suggest particular soundscapes to preserve for future generations. The duration of the test was about 45 minutes. It was carried out with groups of four subjects at a time in a fairly well soundproofed room and under good visual conditions. The equipment comprised a Sony CD Player, a stereopticon and four headphones for the reproduction.

2.4 Correspondence Analysis

The methodical modalities of choice in the answers of the interviewed subjects were recognized on the basis of a correspondence analysis, starting from a 107x38 matrix, where 107 are the interviewed subjects and 38 the associations among sound and image.

3. RESULTS AND DISCUSSION

3.1 Acoustic characteristics of the recorded signals

In Table 1 the acoustic characteristics of the recorded signals are reported in terms of LAeq, the statistic percentile levels L10 and L90 and the difference (L10 – L90).

Table 1: *Acoustic characteristics of the recorded signals.*

Signals / Parameters	Scream	Via Roma	S. Remy Bastion	Cathedral	Marina Piccola	Monte Urpinu	Poetto Beach	Stream
LAeq [dBA]	79,05	70,65	61,65	75,95	53,55	55,55	62,1	59,6
L10 [dBA]	81,8	73,3	64,85	80,25	55,2	57,65	65,1	61,7
L90 [dBA]	67,2	67,1	56,1	53,4	49,9	52,7	54,4	49,1
(L10 – L90) [dBA]	14,6	6,2	8,8	26,9	5,35	4,95	10,7	12,65

3.2 Evaluation of landscapes and soundscapes

Observing Table 2, related to the pleasantness evaluation for the single sounds, for the single images and for the combinations of both, the preference of the subjects for the natural scenes and for the parks rather than for the urban scenes is evident. Sounds in which voices of animals or acoustic events caused by natural phenomena (a little waterfall, waves, wind, billows, gulls)

Table 2: *Average score and standard deviation of separate stimuli and their combinations.*

Images \ Sounds		"Scream" (contr.2)	Via Roma	S.Remy Bastion	Cathedral	Marina Piccola	Monte Urpinu	Poetto Beach	"Stream" (contr.1)	Combi- -nation	Separate Sound
"Scream" (contr.2)	x	1,72	---	---	---	---	---	---	---	---	1,64
	σ	1,01	---	---	---	---	---	---	---	---	0,62
Via Roma	x	---	2,34	3,04	3,22	3,34	3,36	3,43	---	3,12	1,71
	σ	---	0,94	0,73	0,96	0,92	0,82	0,92	---	0,88	0,76
S.Remy Bastion	x	---	2,05	3,33	3,33	3,36	3,58	3,66	---	3,22	2,64
	σ	---	0,86	0,80	1,05	0,88	0,85	0,87	---	0,89	0,78
Cathedral	x	---	1,79	2,69	3,46	3,29	3,56	3,30	---	3,02	3,18
	σ	---	0,66	0,81	1,13	1,02	0,92	1,01	---	0,93	0,97
Marina Piccola	x	---	2,20	3,01	2,88	4,30	3,82	4,29	---	3,42	3,45
	σ	---	0,84	0,81	1,07	0,78	0,88	0,63	---	0,84	0,77
Monte Urpinu	x	---	1,90	2,69	2,93	3,92	4,53	4,09	---	3,34	4,14
	σ	---	0,78	0,94	1,22	0,87	0,59	0,86	---	0,88	0,62
Poetto Beach	x	---	1,90	2,79	2,63	3,95	4,07	4,79	---	3,36	4,63
	σ	---	0,80	0,93	1,16	0,96	0,84	0,43	---	0,85	0,54
"Stream" (contr.1)	x	---	---	---	---	---	---	---	4,83	---	4,43
	σ	---	---	---	---	---	---	---	0,44	---	0,73
Combi- -nation	x	---	2,03	2,93	3,08	3,69	3,82	3,93	---		x=3,23
	σ	---	0,81	0,84	1,10	0,91	0,82	0,79	---		σ=0,72
Separate Image	x	2,28	3,12	3,63	3,36	4,00	4,39	4,41	4,66	x=3,73	
	σ	0,90	0,63	0,68	0,87	0,61	0,63	0,64	0,55	σ=0,69	

predominate, attract greater preference than man-made acoustic places. The score of each separate stimulus is often different from the score of audio/visual combination, and this fact suggests how the sum of two different sensorial stimuli gives an ampler basis of judgment to the interviewed subjects. Hence, the agreeability gradient seems to correlate directly with the presence of natural visual and acoustic components in the landscape. Whenever the natural acoustic components prevail, coherent combinations of sound and image are much more appreciated than each stimulus taken singly.

Comparison of the acoustic parameters of the stimuli with the preferences assigned in the questionnaire, indicates that there is no direct relationship between perception of noise annoyance and intensity of the acoustic signals. If it does exist, this relationship is true for the urban landscapes only, in which, indeed, the degree of agreeability is inversely related to their LAeq. In the natural scenes, contrarily, the students appreciated more the landscapes with an acoustic environment rich in sound signals, rather than the places that evoked an atmosphere of calm and quiet, confirming that silence is not always attractive. The interpretation of the questionnaire data, integrated with the sound spectra information, suggests the following considerations about the environmental qualities of the six selected places. Via Roma: characterized by a squashed acoustic perspective and by *ubiquity* [7] that make it a deceptive soundscape [8]; Saint Remy Bastion: characterized by a strong *metabolic* quality [9]; the Cathedral: characterized by a good *unworldliness* [9] and by an important soundmark [10]; Marina Piccola Wharf: characterized by an atmosphere of quiet; Monte Urpinu: recognized as an acoustic oasis of the city; Poetto Beach: characterized by a vast acoustic horizon and by the presence of several *keynotes* [10].

3.3. Correspondence analysis

The representation of the analysis in the two axes of maximum inertia is described in Figure 2. The statistical validity of the results has been verified through the two control variables, which are positioned to an angle of around 180° with respect to the origin of the axes, showing a correlation equal to -1 (perfect negative association). The 38 points form six well-gathered sets. Each set is characterized by common associated acoustic stimulus (instead the image changes). Therefore the sound, more than the image, has been the critical and predominant element in shaping the interviewed subjects' judgements. A seventh set, large enough and positioned within proximity of the origin, represents the *maximum coherence* set, and contains the eight points in which audio/visual stimuli are congruent with one another. Every time the association is coherent, the point is displaced from the cloud of points to which it belongs, drawing nearer to the origin. For this reason, whenever the association is coherent, the students clearly perceive it in a different way from the rest of the set. This model of analysis, moreover, has allowed to give an intuitive meaning to the three axes, identifying them with three possible parameters of discrimination in the judgment of the interviewees. The X axis represents the landscape types from the urban scenes to the natural ones; the Y axis represents the variation from the Low-Fi landscapes (poor in signals, not very legible, characterized by the presence of strong human activities, and quantitatively by a high L90 and a minor difference between peak and background

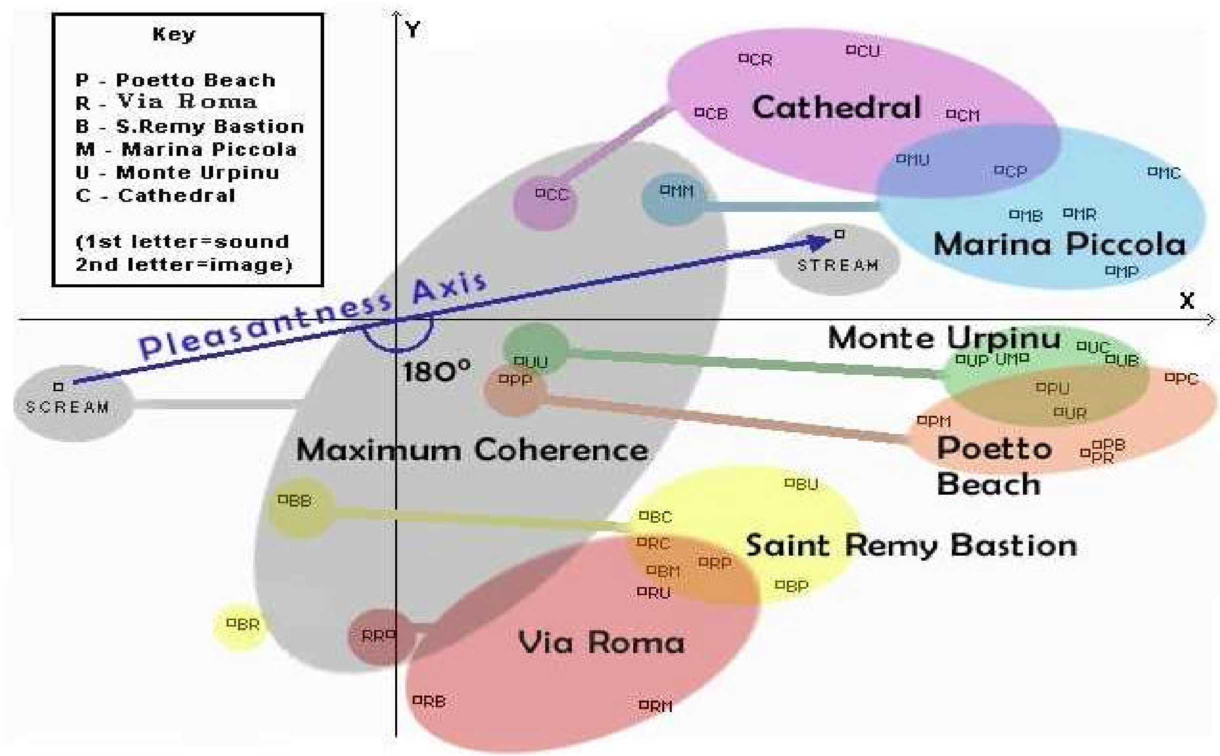

Figure 2. *First and second dimension of the Correspondence Analysis.*

level), to the High-Fi ones (rich in keynotes and acoustic signals, and quantitatively characterized by a low L90 and a major difference between peak and background level and by limited human activity) [10]; the Z axis (not shown in Figure 2) represents the increasing LAeqs.

4. CONCLUSIONS

This research highlights the importance of the contexts in which sound or noise is produced/heard and the meanings that it evokes for the public as a whole. Variables other than the LAeq (such as the peak and background percentile levels and their difference) have all influenced the judgment of the interviewees. Noise evaluation on the basis of LAeq alone implies the risk of cancelling out specific sounds recognized by the public as identifiable in an environmental dimension of their own city (soundmarks), but that overcome the thresholds of admissible LAeq or of underestimating other sounds that do not overcome such thresholds, but which could be annoying in that they mask more important sounds. The research suggests a prediction function for the urban planning, when it is required to study the appreciation given to a place in relation to future changes, and it proposes some prerequisites, that could be necessary for drawing up an Acoustic Plan or indeed any planning measures that involve the human perceptive and experiential dimension, particularly the auditory one, in the organization of space.

ACKNOWLEDGEMENTS

Study carried out in the framework of projects conducted by IGAG - CNR (Environmental Geology and Geoengineering Institute of the National Research Council), Cagliari, Italy.

REFERENCES

1. S.J. Thompson, EU's Future Noise Policy, WG2 – Dose/Effect, State of knowledge, Psychophysiological effects of environmental noise and dose-response relationships, Internal report, February 1999.
2. B. Truax, Acoustic Communication, Ablex Publishing, Norwood 1984, pp. 57-83.
3. P. Pittaluga, Progettare con il territorio, Angeli, Milano 2001, 127 pp.
4. J.L. Carles, I. López Barrio, J. V. de Lucio, Sound influence on landscape values, *Landscape and Urban Planning* **43**, pp. 191-200, (1999).
5. A. Farina, An example of adding spatial impression to recorded music: signal convolution with binaural impulse responses, in *Proceedings of Acoustics and Recovery of Spaces for Music*, Ferrara, 1993.
6. A. Farina, M. Postillo, V. Tarabusi, L. Tronchin, Binaural hearing and its numerical representation with an Eulerian approach, in *Seventh International Congress On Sound And Vibration – ICSV7,* Garmisch-Partenkirchen, 2000.
7. J.F. Augoyard, H. Torgue (eds.) A l'écoute de l'environnement. Répertoire des effets sonores, Editions Parenthèses, Marseille 1995, 174 pp.
8. R.M. Schafer, Voices of tyranny, temples of silence, ARCANA editions, Vancouver 1993, 168 pp.
9. P. Amphoux, L'identité sonore des villes européennes. Guide méthodologique à l'usage des gestionnaires de la ville, des techniciens du son et des chercheurs en sciences sociales, IREC, Lausanne, 1993.
10. R.M. Schafer, The Tuning of the World, Knopf, New York 1977, pp. 43-56.