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Livingscape: a multi-sensory approach to improve the quality of urban spaces

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Abstract

The urban environmental quality of two districts in Turin was studied through a livingscape approach, involving an integrated subjective and objective field analysis of soundscape, lightscape, thermalscape and airscape. Aspect such as pleasantness, calmness and vibrancy were investigated. The analysis was aimed at comparing the results which were found for the two districts, with the goal of validating this methodology to be used for the requalification of the areas, through the identification of pleasant and unpleasant urban areas using criteria other than the ones that are currently adopted by specialists and which have a limited relevance on open space comfort.

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Keywords: livingscape; soundscape; lightscape; thermalscape; questionnaire; perception of urban spaces, urban environmental quality

1. Introduction

The spatial and environmental quality of public open spaces has more and more become an essential part of urban culture. In this context, the interaction between sound, light, thermal and air environments is a key factor in the evaluation of the overall environmental quality of a space. In response to this, the livingscape approach (urban blight, soundscape, lightscape, thermalscape) can be an important support to urban planning and management, as it analyses the urban quality through in situ measurements and questionnaires [1-2]. In this context, this paper presents an experimental study on the livingscape which was carried out in Turin (Italy, 45°N). To account for the

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multidimensional character of the urban quality in towns, the livingscape was evaluated through an integrated analysis which involved three aspects: 1) psychometric tools to collect users' judgments on how they rate the environmental quality they perceive in different spaces, through a purpose-questionnaire; 2) aspects related to the urban blight, concerning livability and quality of life, architectural and urban assessments, social life, physical environment, security, activities and utilities, place identity and site arrangement; 3) an objective investigation of the environmental quality through the measurement of acoustic, visual, thermal and IAQ physical parameters.

The study was applied in two districts of Turin (northern Italy): a central historical area and a semi-central area. In both cases, the livingscape was intended as a tool to help the requalification of the areas, detecting the urban key-spaces where some of the environmental quality aspects need to be improved. In particular, aims of the work were:

- to compare the findings which were obtained for the two districts, to identify the most remarkable peculiarities
- to validate the methodology as a potential supporting tool for urban planning, using criteria other than the ones that are currently adopted by specialists and which have limited relevance on open space comfort
- to differentiate between pleasant and unpleasant urban areas, identifying a priority list of interventions.

2. Case-studies

The experimental study aimed at the evaluation of livingscape was applied to two different districts in Turin:

- the 'San Salvario' district: a central historical area, built in 19th century and presently hosting multi-ethnic residents with a high number of amenities and facilities for both day and night entertainment
- the 'Barriera di Milano' district: a semi-central area built in early XX Century, mainly a residential area, with a reduced presence of amenities and facilities for people entertainment and many multiethnic activities.

From an historical analysis (based on archival, cartographic, literary and documentary) from the 19th century onwards, 13 key-spaces (10 streets, 2 squares and an arcade) were selected to characterize past and present district livingscape for San Salvario, while 11 key-spaces (9 streets, 2 squares) for Barriera di Milano. These were grouped in nodes, paths and edges based on Lynch's mental mapping approach [3] (Fig. 1). The classification in edges, paths and nodes was for an initial assumption based on a geometrical parameter, the Slenderness Index SI (i.e. the ratio of the average height of buildings to the street width): $SI \leqslant 0.4$ for edges, $0.4 < SI \leqslant 0.8$ for nodes, $SI > 0.8$ for paths.

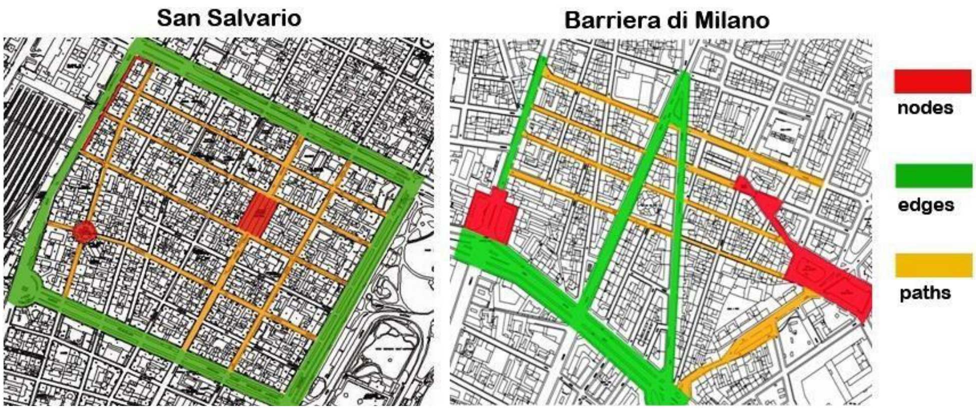

Fig. 1. Maps of the districts analyzed, visualizing nodes, paths and edges.

3. Method

Every key-space was further subdivided into 30 m long parts [4]: for each sector, urban blight evaluations, environmental measurements and user judgments through questionnaires (soundscape, lightscape, thermalscape) were carried out to investigate the livingscape [5-7]. The field campaigns were first conducted in San Salvario during a week (both workdays and holidays) in Sept. 2010 and Febr. 2011, from 10 until 14 during the day and from 20 until midnight during the night. The study was then replicated in Barriera di Milano in Dec. 2013 and Dec. 2014.

3.1. Objective measures

Acoustical parameters were measured through soundwalks. To investigate the key-spaces, binaural audio signals (16 bit/44.1 kHz) were recorded with a portable two-channel device "M-Audio Microtrack 24/96" and with binaural headphones “Sennheiser MKE 2002”. A total of 40 binaural recording files of 10-15 minutes and 40 punctual noise levels 10 minutes long were measured during summer and winter period, in the daytime and nighttime. The files were then uploaded to the elaboration software dBSonic to calculate the Leq (dBA) and psychoacoustic parameter for each part [7]. Light and thermal measurements were carried out at the same time as the acoustical measurements.

Lightscape parameters were measured in terms of horizontal (E_{hor}), vertical (E_{vert}) and cylindrical (E_{cyl}) illuminances and of correlated color temperature (CCT), using a chroma-meter Minolta CL-100. For each measure point, one E_{hor} (1 m above the street level), one E_{cyl} value (eyes’ level), two vertical illuminances (along and opposite to the direction of view) and three CCT values were taken. Furthermore, the Sky View Factor SVF (a measure of solid angle of sky seen from the point) was calculated using Ecotect. A value of SVF equal to 1 means that there is an unobstructed view of the sky, while SVF=0 means that the view of the sky is totally obstructed.

Thermal- and airscape parameters were measured in terms of air temperature, air velocity and relative humidity using an anemometer. Pictures and video were also recorded for each measure point to correlate field data with GIS data and satellite images to construct realistic representations.

3.2. Survey

The questionnaire consisted of 32 items, subdivided into three sections:

i) a section addressed general information on the interviewees: gender, age, place of residence, profession, nationality, allergies and respiratory illnesses, number of years spent in the area, reasons for attendance and use of the place; questions also proposed adjectives used to describe the urban space (12 options)

ii) a section aimed at collecting opinions on sound, light, thermal and air environments, with regard to: a) annoyance with sound (luminous, thermal) environment, on a 5-point scale with labels ‘not at all’, ‘a little’, ‘moderately’, ‘much’ and ‘extremely’; b) pleasantness with sound (luminous, thermal) environment, on a continuous scale between ‘extremely unpleasant’ and ‘extremely pleasant’; c) calmness/relaxation of the sound (luminous, thermal) environment, on a continuous scale between ‘agitating, stressing, etc.” and ‘calm, peaceful, etc.’; d) vibrancy of the sound (luminous, thermal) environment, on a continuous scale between ‘gloomy, boring, etc.’ and ‘fun, exciting, etc.’; e) thermal perception, on a 7-point discrete scale between ‘very cold’ and ‘very hot’; f) air humidity, on a 5-point discrete scale between ‘very dry’ and ‘very humid’. Furthermore, users were asked to rate the environmental quality they globally perceived in the urban space (‘global pleasantness’)

iii) a section on the importance attributed to acoustical, light, thermal, air comfort and quality of the space: each item was assessed through a 5-point scale with labels ‘very low’, ‘low’, ‘average’, ‘high’ and ‘very high’. Users were also asked to rank these aspects in order of importance. They were also asked to rank the importance attributed to aspects such as ‘pedestrian/bike paths’, ‘commercial/entertainment activities’, ‘playgrounds for kids’, ‘vegetation’, ‘sport areas’, ‘areas with benches for rest and conversation’.

Questionnaires were submitted in the same points as field measurements. Some 496 (240 in summer and 256 in winter) and 416 questionnaires were collected in ‘San Salvario’ and in ‘Barriera di Milano’, respectively.

All the data collected through the questionnaires were statistically analyzed analyses using the SPSS® package.

4. Results and discussion

4.1. Objective results

A factorial analysis was carried out on measured data, using a Principal Component Analysis, PCA, with varimax rotation and Kaiser normalization, to identify a small number of latent factors that would be able to describe and summarize the whole sample and its main aspects, to be used for further analyses. The analysis was carried out grouping together summer/winter and day/night periods. For the light environment analysis only, day and night-time were considered separately to account for the difference between daylight and electric light. For both district, analyzed separately, the factorial analysis singled out the same factors. For the sound environment, four acoustical factors were extracted, which explain 85.7% of the variance. These factors can be associated to four different sound aspects, labeled as: 1) 'Intensity' (6 items); 2) 'Fluctuation' (3 items); 3) 'Sharpness' (3 items); 4) 'Roughness' (3 items). As far as the light environment is concerned, the same three lighting factors were extracted for both for day- and night-time, which explain 77.8% and 86.1% of the variance, respectively: 1) 'Illuminance' (vertical illuminance on the two sides of the path, horizontal illuminance and cylindrical illuminance); 2) 'Color temperature' (three correlated color temperatures corresponding to the illuminance measurement sides); 3) 'Spaciousness' (SI e SVF). Three uncorrelated factors, recognized as 'Temperature', 'Wind speed' and 'Relative humidity' were singled out from this analysis to explain the variability of the thermal aspects.

4.2. Questionnaires

ANOVA tests were performed on the different key-space categories (edges, paths and nodes) in order to detect whether there were any significant differences with a 1% of risk level, between the night/day time and summer/winter period related to the subjective pleasantness, calmness and vibrancy of the different environments. The relative p-values are shown in Table 1 for both districts. The pleasantness and calmness values related to the sound and light environments show differences between key-space categories. It should be pointed out that the higher variance in the sound pleasantness scores, compared to the variance in the other environmental aspects, shows that the sound environment is more relevant for the interviewees. As expected, the light and thermal subjective items show differences between day and night, and thermal pleasantness is influenced by season (even though this investigation was carried out for the San Salvario district only). As far as the comparison between the two districts is concerned, it is worth noting that the results are, on the whole, consistent for the two areas. Only a few differences emerge: for instance, with reference to the key-space categories, the vibrancy of sound environment was significant in 'Barriera di Milano' and not significant for 'San Salvario', while the opposite applies to the pleasantness of the sound environment.

Table 2 shows the correlations between subjective judgments which were expressed for the different environmental aspects investigated. For the district of San Salvario, a low amount of statistically significant correlations was observed. The outstanding findings were concerned with acoustical parameters: the environmental quality globally perceived resulted positively correlated with aspects of the sound environment, in terms of pleasantness and calmness. Furthermore, the pleasantness of the sound environment showed a negative correlation with the annoyance with the sound environment (the higher the annoyance, the lower the pleasantness perceived). An inverse correlation between pleasantness and annoyance, unlike one might have expected, was not found for the luminous environment. This latter correlation was found also for the district 'Barriera di Milano'. For this area, though, no correlation was observed between the global pleasantness and any other environmental aspect.

The subjective scores were then correlated with the scores of the objective environmental factors identified with a PCA (see Table 1). The scores of the objective factors relative to the environmental factors identified through the PCA were then correlated with the subjective scores. Table 3 shows the significant correlations which were found between factors of sound aspects and subjective items on environmental perception. The 'Intensity of the sound' factor resulted positively correlated with annoyance due to the soundscape. As far as lightscape is concerned, high illuminance during the night is correlated with a decrease in the annoyance and with an increase in the vibrancy with the lightscape, while the CCT resulted the most important factor during the day: it is positively correlated with pleasantness, calmness and vibrancy of lightscape.

The "a-priori" classification of the key-spaces in "nodes", "edges" and "paths", which was done on the basis of the historical, urban planning and geometrical investigation, was confirmed by the resulting cluster analysis. A hierarchical cluster analysis was carried out (applying the Ward algorithm for agglomerative clustering, Euclidean distance and the range of solutions between 2 and 4 clusters) to differentiate the key-spaces with respect to the sound pleasantness. The analysis was based on average sound and light pleasantness during day/night as well as in summer/winter for the district 'San Salvario', during day/night only in the district 'Barriera di Milano'. After looking at the resulting dendogram and at the distances between the clusters, two well separated clusters were identified to classify the key-spaces: they were therefore subdivided into 'pleasant' (paths SI>0.8) and 'less pleasant' (edges and nodes, SI≤0.8) and this result was the same for both districts (Fig. 2).

Table 1. P-values related to an ANOVA test on the hypothesis of equal means among the different key-space categories and between the day and night and the summer/winter. Significant differences (p-values<0.01) are highlighted in bold.

	SAN SALVARIO			BARRIERA DI MILANO	
name	key-space category	day/night	summer/winter	key-space category	day/night
Pleasantness of sound environment	**0.00**	0.25	0.51	0.03	0.07
Calmness of sound environment	**0.01**	0.79	0.72	**0.00**	0.99
Vibrancy of sound environment	0.04	0.60	0.80	**0.00**	**0.01**
Pleasantness of luminous environment	**0.00**	**0.00**	0.66	**0.01**	**0.00**
Calmness of luminous environment	**0.01**	**0.00**	0.21	**0.00**	**0.00**
Vibrancy of luminous environment	0.21	**0.00**	0.91	**0.01**	**0.00**
Pleasantness of thermal environment	0.72	**0.00**	**0.00**	0.07	0.72
Pleasantness of air quality	0.59	0.10	0.76	**0.00**	0.40

Table 2. Correlation between subjective scores expressed on annoyance, pleasantness, calmness and vibrancy for the different environments. Significant correlations (coefficients p-value<0.05) are highlighted in bold.

	global pleasantness	annoyance with sound environment	pleasantness of sound environment	calmness of sound environment	vibrancy of sound environment	annoyance with luminous environment	pleasantness of luminous environment	pleasantness of thermal environment	pleasantness of air quality
SAN SALVARIO									
global pleasantness		-0.478	**0.619**	**0.882**	-0.055	-0.473	0.299	-0.371	0.503
annoyance with sound envir.	-0.478		**-0.719**	-0.578	-0.102	0.295	0.167	0.576	-0.388
pleasantness of sounds envir.	**0.619**	**-0.719**		**0.737**	-0.078	-0.226	0.280	-0.567	0.581
calmness of sound envir.	**0.882**	-0.578	**0.737**		-0.076	-0.496	0.325	-0.549	0.456
vibrancy of sound envir.	-0.055	-0.102	-0.078	-0.076		-0.348	-0.123	0.085	-0.545
annoyance with luminous envir.	-0.473	0.295	-0.226	-0.496	-0.348		0.037	0.498	-0.048
pleasantness of luminous envir.	0.299	0.167	0.280	0.325	-0.123	0.037		-0.427	0.406
pleasantness of thermal envir.	-0.371	0.576	-0.567	-0.549	0.085	0.498	-0.427		-0.561
pleasantness of air quality.	0.503	-0.388	0.581	0.456	-0.545	-0.048	0.406	-0.561	
BARRIERA DI MILANO									
global environmental quality		0.051	-0.201	-0.088	-0.225	-0.126	-0.149	-0.221	-0.029
annoyance with sound envir.	0.051		**-0.604**	**-0.616**	0.215	0.393	0.050	-0.018	-0.544
pleasantness of sounds envir.	-0.201	**-0.604**		**0.785**	0.138	-0.253	0.309	0.027	0.327
calmness of sound envir.	-0.088	**-0.616**	**0.785**		-0.052	-0.179	0.075	-0.086	0.385
vibrancy of sound envir.	-0.225	0.215	0.138	-0.052		0.191	0.386	0.225	-0.356
annoyance with luminous envir.	-0.126	0.393	-0.253	-0.179	0.191		-0.295	0.030	-0.449
pleasantness of luminous envir.	-0.149	0.050	0.309	0.075	0.386	-0.295		0.099	0.057
pleasantness of thermal envir.	-0.221	-0.018	0.027	-0.086	0.225	.0300	0.099		-0.144
pleasantness of air quality.	-0.029	-0.544	0.327	0.385	-0.356	-0.449	0.057	-0.144	

Table 3. Significant correlations between the environmental factors and the subjective items pertaining to the perception of the environment. Significant correlations (correlation coefficient r ≥ |0.20| with a significance level of 1% - p-values<0.01) are shown.

SOUND-SCAPE	annoyance with sound environment	pleasantness of sound environment	calmness of sound environment	vibrancy of sound environment	LIGHT-SCAPE	annoyance with luminous environment	pleasantness of luminous environment	calmness of luminous environment	vibrancy of luminous environment
Intensity	0.215				Illuminance_night	-0.351			0.541
Fluctuation					Color temperature_day		0.286	0.273	0.272
Sharpness					Color temperature_night				
Roughness					Spaciousness				

The resulting discriminant scores and predicted group membership values, obtained with the Fisher linear discriminant method, led us to conclude that the objective acoustical factors do in fact give rise to the same classification of the key-spaces obtained with sound pleasantness and the same for the light, except for Madama Cristina street in San Salvario and Piazza Bottesini and Corso Palermo in Barriera, which were not confirmed. These key-spaces are exceptionally busy streets with many activities and car and bus traffic which make them similar to edges from the objective viewpoint.

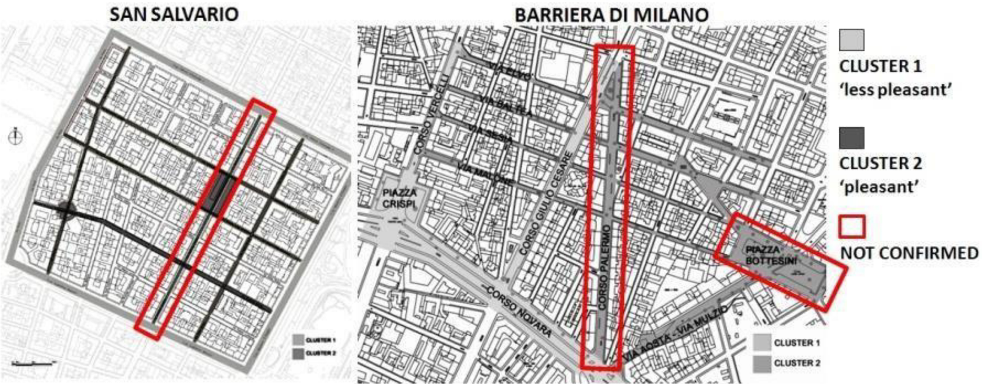

Fig. 2. Comparison of 'pleasant' and 'less pleasant' key-spaces for the 2 districts analyzed. This distinction was based on the subjective judgments which were expressed on soundscape and lightscape.

5. Conclusions and future work

The livingscape approach, consisting of soundscape, lightscape, thermalscape and airscape, was applied to two districts in Turin (one central, full of activities and with a historical character, one semi-central and basically residential), with the aim of assessing how the environmental quality of urban spaces is perceived by users. Many results which were found were basically the same for the two districts: for instance, the same factors were extracted from a factorial analysis using a Principal Component Analysis: 'Intensity', 'Fluctuation', 'Sharpness', 'Roughness' for soundscape; 'Illuminance', 'Color temperature', 'Spaciousness' for lightscape (both during day and night-time). Or, the pleasantness of the sound environment showed a negative correlation with the annoyance with the sound environment. For San Salvario only, the environmental quality globally perceived resulted positively correlated with aspects of the sound environment, in terms of pleasantness and calmness. Two well separated clusters have been chosen to classify the key-spaces with respect to the sound pleasantness. The first cluster, characterized by lower pleasantness, groups the key-spaces recognized as both edges and nodes, while the second cluster groups the key-spaces identified as paths. A discriminant analysis that considers the objective acoustical factors instead of the sound pleasantness scores confirms the same key-space classification, and determines that higher Intensity factor values and lower Fluctuation factor values result in lower sound pleasantness scores.

Based on the results of this study, the livingscape methodology proved to be a useful tool to assess how urban spaces are perceived by the citizens: therefore, it can be a tool support the urban planning especially in the requalification process of urban areas. In this regard, the huge amount of data, both objective and subjective, collected in-the-field, could be included in urban and building geo-referencing website. The livingscape methodology has other potential applications: strategies could be defined to enhance urban orientation or to highlight pleasant and less pleasant paths, nodes and edges both for tourism and for people with impairments.

References

[1] P. J. Littlefair et al.. Environmental Site Layout Planning: Solar Access. Microclimate and Passive Cooling in Urban Areas (Building Research Establishment Report 380. London) (2000).

[2] RUROS (Rediscovering the Urban Realm and Open Spaces). Progettare gli spazi aperti nell'ambiente urbano: un approccio bioclimatico. Grecia, Centre for Renewable Energy Sources (CRES) 2004, 32-36.

[3] Lynch K. The Image of the City. MIT Press. Cambridge. 1960.

[4] Di Gabriele M. Maffei L. Aletta F. Urban Noise Mapping Based on Emotional Dimensions. In: Proc. "1st EAA – EuroRegio Congress on sound and vibration". Ljubljana. September 15-18. 2010. 75.

[5] La Malva F. Astolfi A. Lo Verso VRM. Bottalico P. City's quality of life based on livingscape approach (urban blight. soundscape. light-scape. thermic-scape. subjective replies of users) to improve an urban historical place. in Proc. Forum Acusticum 2011. Aalborg. June 26 – July 1. 2011. 314.

[6] La Malva F. Astolfi A. Bottalico P. Lo Verso VRM. Bronuzzi F. Livingscape approach to improve urban historical places. Journal of Temporal Design (2011), 20-24.

[7] La Malva F. Astolfi A. Bottalico P. Lo Verso VRM. Bronuzzi F. Livingscape multi-sensory experience in urban historical places: subjective assessment from the local people and quality of the urban environment. Journal of Temporal Design (2011), 25-29.