Characterization of the soundscape in Valley Gardens, Brighton, by a soundwalk prior to an urban design intervention

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Summary

The purpose of the present study was to characterize the soundscape of the Valley Gardens in Brighton before the area is converted into a downtown park. Valley Gardens is located in the busy city centre. It extends from the Brighton Pier at the seafront and approximately 1.5 km to the north. It includes Old Stein, Victoria Gardens, St Peter's Church, and The Level. In 2015 work will commence on redeveloping Victoria Gardens and St Peter's Church. In order to characterize the soundscape of the Valley Gardens prior to this urban design intervention a soundwalk was conducted. In October 2014, a group of 21 persons -experts in acoustics and officers of the City Council- were guided through the area together, and assessed the soundscape at eight sites: five within the Valley Gardens and three reference sites. The assessments covered the soundscape quality, how appropriate the soundscape is to the place, the dominance of perceived sound sources, and the affective quality of the soundscape. In addition, binaural recordings and sound-level measurements were conducted at each of the eight sites during the soundwalk. Preliminary results indicate that the Valley Gardens was dominated by the sound of road traffic, and that the soundscape was perceived as inappropriate to the place. Consequently, the planned design intervention should reduce the dominance of road-traffic sound and introduce more positive sounds, like the sound of people and nature. This would be done through careful planning of the landscape and human activities within the area. The plan is to follow-up these results with a post-intervention soundwalk.

PACS no. 43.50.Qp, 43.50.Rq, 43.66.Lj

1. Introduction[1]

Brighton & Hove (UK) is a city with 250,000 residents. In spite of a deceleration moment in the latter decades of the twentieth century, tourism is now growing again and is certainly one of the main development factors for the city. Brighton & Hove offers a wide range of restaurants, bars and clubs, as well as cultural events. The setback of being such a thriving city with pressures from tourism and night time economy, against the demands of residents activities are the noise issues. The city centre is affected by noise from human activities and in particular from road traffic.

Figure 1. Study area (yellow line), the 8 points of the soundwalk (ref. pts. in red) and some participants.

In recent years, the City Council of Brighton & Hove has always been proactive about soundscape and noise related issues in general [1,2] and currently it is a city partner within the SONORUS project. The project aims to develop a new holistic approach on urban sound planning. Within the SONORUS project, each city partner had to identify a test site. The test site selected by Brighton & Hove City Council is Valley Gardens, an urban park located in the city centre that goes from the seafront roundabout (Brighton's pier) to approximately 1.5 km into the City. The area suffers from a very poor acoustic environment that is highly affected by traffic noise. The green areas along the site are not used by the residents for their leisure activities. Therefore, the City Council has defined a project to improve the area –The Valley Gardens project– that involves the transformation and complete redesign of the site. According to the city description, "SONORUS researchers will be working with senior planners, highway engineers and landscape professionals as well as exploring the potential areas to host cultural and arts based event of a temporary and permanent nature, for improving the perception of the sonic environment.

During the project meeting in Brighton (October 2014) a soundwalk session was carried out in the test site. Twenty persons –experts in acoustics and officers of the City Council– took part in the soundwalk. Binaural recordings and sound levels measurements were also performed during the soundwalk, in order to analyse the relationships between objective parameters and individual responses [3-7].

The aim of this paper was to characterise and reveal the current soundscape of the area, before any intervention is undertaken. For this purpose, a GIS-based process was implemented in order to visualise different maps related to the individual responses. The same procedure is expected to be repeated, as the interventions for noise mitigation and/or improvement of the sonic environment will take place, in order to monitor the variation of soundscapes over time and assess the effectiveness of the applied solutions.

2. Methods

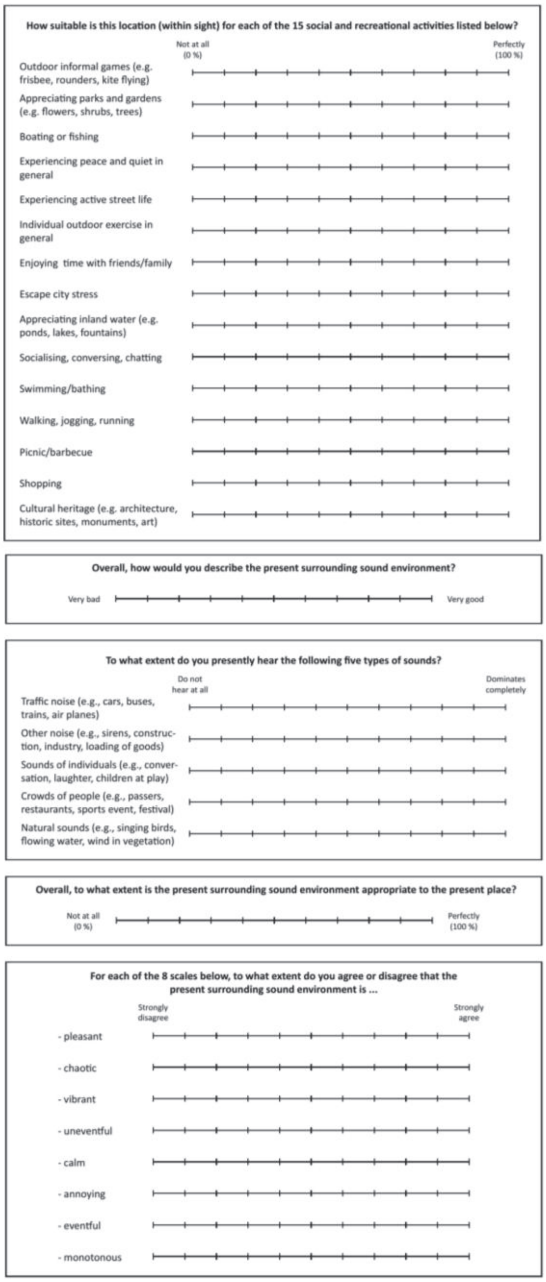
2.1. Participants

Twenty-one persons, 25 to 68 years old, participated in the soundwalk (5 women, 16 men; M_{age} = 38.7 years, SD = 11.5). Participants were acousticians, architecture and planning professionals and officers from Brighton & Hove City Council. Seventeen participants were not residents in the United Kingdom, while four participants were residents in Brighton & Hove.

2.2. Soundwalk

The soundwalk took place on a Monday morning from 09:30 to 10:30 am. The experimenters led the participants by walking across the study area and stopping at eight selected locations; these were: (1) Seafront, (2) The Old Steine, (3) Royal Pavilion, (4) Victoria Gardens South – Victoria Statue, (5) Victoria Gardens South – Mazda Fountain, (6) Victoria Gardens North, (7) St Peter's Church and (8) The Level (Fig. 1). Locations (1), (3) and (8) were considered as reference sites since they will not be affected by the planned interventions. For each location, participants were required to listen to the acoustic environment for a 2-minute time and to fill in a structured questionnaire (Fig. 2).

During the soundwalk, a non-participant operator carried out some binaural recordings by means of two 1/8" in-ear microphones (DPA, frequency



How suitable is this location (within sight) for each of the 15 social and recreational activities listed below?

Not at all (0 %) — Perfectly (100 %)

Outdoor informal games (e.g. frisbee, rounders, kite flying)
Appreciating parks and gardens (e.g. flowers, shrubs, trees)
Boating or fishing
Experiencing peace and quiet in general
Experiencing active street life
Individual outdoor exercise in general
Enjoying time with friends/family
Escape city stress
Appreciating inland water (e.g. ponds, lakes, fountains)
Socialising, conversing, chatting
Swimming/bathing
Walking, jogging, running
Picnic/barbecue
Shopping
Cultural heritage (e.g. architecture, historic sites, monuments, art)

Overall, how would you describe the present surrounding sound environment?

Very bad — Very good

To what extent do you presently hear the following five types of sounds?

Do not hear at all — Dominates completely

Traffic noise (e.g., cars, buses, trains, air planes)
Other noise (e.g., sirens, construction, industry, loading of goods)
Sounds of individuals (e.g., conversation, laughter, children at play)
Crowds of people (e.g., passers, restaurants, sports event, festival)
Natural sounds (e.g., singing birds, flowing water, wind in vegetation)

Overall, to what extent is the present surrounding sound environment appropriate to the present place?

Not at all (0 %) — Perfectly (100 %)

For each of the 8 scales below, to what extent do you agree or disagree that the present surrounding sound environment is ...

Strongly disagree — Strongly agree

- pleasant
- chaotic
- vibrant
- uneventful
- calm
- annoying
- eventful
- monotonous

Figure 2. The questionnaire used for the soundwalk

range 20 Hz – 20 kHz) connected to a portable high-resolution audio recorder (722 Sound Devices). The operator attended the soundwalk together with the other participants and recorded a 2-minute audio sample at each of the eight selected locations. The eight audio samples were afterwards collected and the main statistical noise levels were calculated.

2.3. Statistical analysis

The investigated sound environment was evaluated using statistical analysis applied for two groups of variables: (a) the individual responses and (b) the acoustic metrics. The software R was used to perform the analysis. In the first group the variables of the overall soundscape appraisal, the appropriateness of the sound environment, the dominance of perceived sound sources, and the affective quality of the soundscape are involved. The second group includes the acoustic metrics (L_{Aeq}, L_{max}, L_{min}, L_{10}, L_{50}, L_{90}, L_{10}-L_{90}) calculated from the audio recordings in each location.

Pearson's correlation tests were applied to evaluate the association between variables. The analysis to assess the relation between the variables consisted of two stages. For the first stage, the individual responses of each subject at each location were considered with the corresponding acoustic metrics. In total, 160 evaluations were examined in the analysis and 8 were rejected, because of missing data in the questionnaires.

For the second stage, the mean values of the responses in each location were evaluated and 8 cases were used in the analysis. A within-subjects ANOVA was conducted in order to detect significant differences between the 8 locations, in terms of individual responses [8]. A post-hoc test was then applied to determine which groups significantly differ from each other. The analysis was followed-up by sets of paired-samples t-tests.

2.4. Soundscape mapping process

A prediction surface based on the answers from the participants at the 8 points was created using the kriging interpolation method applied in ArcGIS (v.10.1). Kriging has already been used for noise mapping, as well as for soundscape purposes (see e.g. [9,10]). In this case, the surfaces were created based on the Ordinary Kriging method and the spherical semivariogram model, taking into account all the 8 points of the study area. The colour scale of the maps varies from 0 to 10, following the range of the answers in the questionnaire. However, in order to have comparable maps and accurate visual representation even for very low variances, it was decided to divide the initial scale (0-10) in 20 equal parts, with a unique colour representation for each part.The variables evaluated consist of the individual responses described in § 2.3 and the activity variables in the questionnaire.

3. Results and discussions

3.1 Correlations between acoustic metrics and individual responses

The soundscape analysis was conducted with data from both the acoustic metrics and the individual responses. Results include the correlation coefficients between parameters within the same or different group and the difference of perceptual parameters among the 8 locations. Pearson's correlation coefficients as well as the corresponding p-values are reported for both stages of analysis, considering first the mean values per site (r_1, p_1) and then considering all the individual responses while accounting for the differences in each place (r_2, p_2).
For the evaluation of the environment two of the variables were used: (a) subjective judgment of the overall surrounding sound environment and (b) the appropriateness of the environment. Results show that between these two variables there is a significant positive correlation (r_1=.955, p_1<.001), (r_2=.707, p_2<.001). These results signify that high levels in the parameter of appropriateness are necessary in order to positively assess the quality of an environment.
It is also interesting to note the relation between the above mentioned variables and one of the physical parameters, L_{A50}. Considering all the tested acoustic metrics, L_{A50} has the highest absolute correlation coefficients with the above mentioned perceptual variables (a) and (b): (r_1= -.842, p_1=.009), (r_2= -.622, p_2<.001) and (r_1= -.845, p_1=.008), (r_2= -.506, p_2<.001), respectively.
Furthermore, previous reported studies [3,6] also found L_{A50} to be the most suitable indicator for quietness. Similarly, it was also observed that the indicator with one of the highest absolute correlation coefficient values for all the reviewed physical indicators is L_{A50} for both chaoticness and calmness ,with values (r_2=.512, p_2<.001) and (r_2=-.644, p_2<.001). Moreover, when comparing the correlation coefficients between the overall surrounding sound quality and the appropriateness with all of the eight emotional parameters it could be noted that the high correlation was observed with all of the cases (Table I).
Another interesting fact is that chaoticnesss is positively correlated with the presence of traffic sounds (r_1=.985, p_1<.001), (r_2=.549, p_2<.001); however a negative correlation is observed with sounds from individuals (r_1=-.876, p_1=.004), (r_2=-.263, p_2=.001) and crowds (r_1=-.707, p_1=.05), (r_2=-.141, p_2=.074).
Therefore, these results suggest that the participants considered human sounds as a positive factor towards the evaluation of environmental calmness. In comparison to the research related to the perception of 'tranquillity', the current results might be explained as the participant associated tranquillity/quietness with social relationships i.e. *"with the desire of sharing with others in quiet areas"* [11].
Additionally, an analysis was conducted on the overall statistical difference between the sites. All the eight sites were evaluated. Nevertheless, when considering all the soundscape perceptual parameters, only two sites, namely site 3 and 8 show a significant difference with four or more sites for three or more parameters.
The results presented in this study display similarities with previous conducted research [1-3]. Furthermore, it should be noted that they cannot be considered biased, because of the high plurality of the participants and the low percentage of local residents. The latter could have unintentionally overestimated the negative impact of the current condition, compared with other places around Brighton. Therefore one has to be careful when considering the results as a point of reference to the more general public of Brighton residents and tourists because of the similarity in the investigated group profile. Nevertheless, the data presented might be a valid reference when proposing new solutions and improvements to the site area.

Table I. Pearson's Correlation coefficients (p<0.001) between overall sound quality and appropriateness with the chaoticness and calmness.

	n = 8		n = 160	
	Ov. SQ	App.	Ov. SQ	App.
Chaoticness	-.987	-.982	-.987	-.982
Calmness	.969	.947	.969	.947

3.2 Soundscape maps

From the kriging interpolation it can be observed that out of the 8 sample points in the study area, sources related to traffic are the most dominant along the entire park (Fig. 3a). On the contrary, natural sources were evaluated with low scores (Fig. 3b). The low results in the maps of 'sounds of crowds' and 'sounds of individuals' (Fig. 3c-d), except for point 8, suggest the absence of activities or motives that would prompt people to spend time in the park.
The entire area was poorly evaluated as 'pleasant' or 'calm' (Fig. 4a,c) with the outliers being again the points 3 and 8. Negative emotional parameters such as 'chaotic' and 'annoying' (Fig. 4b,d) present high values throughout the entire area and particularly for points 1, 5 and 6, which are

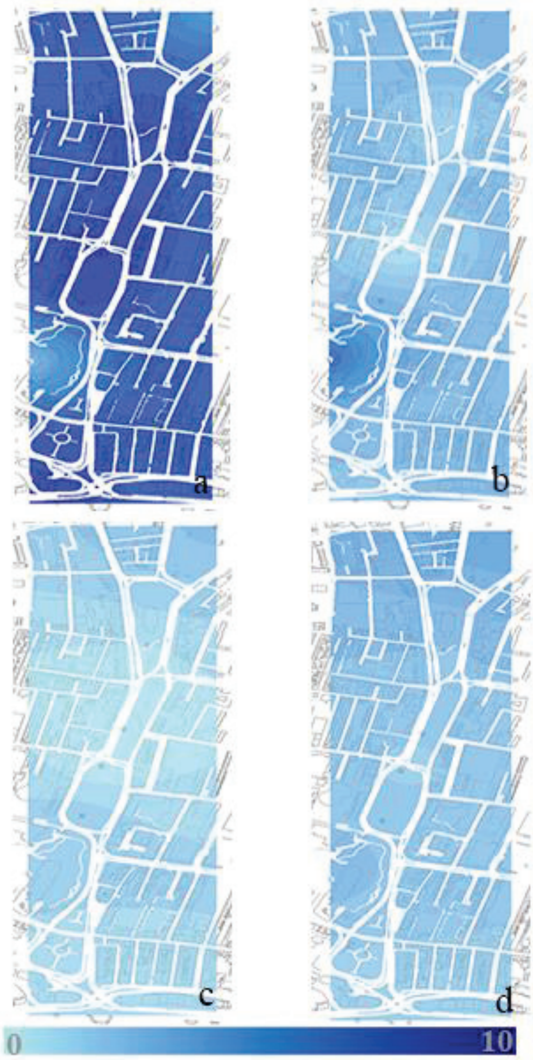


Figure 3. Sound source dominance maps: Traffic (a), Natural sounds (b), Sounds of crowds (c), Sounds of individuals (d).

dominated by road traffic. The variables ‘eventful’ and ‘monotonous’ present the lowest variability among the emotional parameters (Fig. 4e,f), with no significant peaks or lows and levels close to the median. These neutral changes suggest the lack of a particular sonic identity in the area.

In the Activity group (Fig. 5) the entire area was assessed as more privileged in the sector of physical activities, such as ‘outdoor gaming”, ‘walking-running’ and ‘outdoor exercise’. Lower values were reported in the areas for the variables ‘escaping city stress’,’ socializing’, ‘inland water appreciation’ and ‘picnic’. Two distinguishable focal patterns appear in point 3 for city stress and point 2 for inland water appreciation, possibly because of the active fountains.

4. Conclusions

This study aimed at characterizing the soundscape of Valley Gardens (Brighton) prior to an urban design intervention. Acoustic metrics as well as individual responses to the acoustic environment were collected during a soundwalk. In order to represent the data, a number of perceptual maps were produced through a GIS-based interpolation technique. Results showed that the Valley Gardens area was dominated by the sound of road traffic, and that the soundscape was perceived as inappropriate to the place.

Consequently, the planned design intervention should reduce the dominance of road-traffic sources and introduce more positive sounds, like the sound of people and nature. This can be done through careful planning of the landscape and the human activities within the area. The plan is to follow-up these results with a post-intervention soundwalk.

Acknowledgements

The research leading to these results has received funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013 under REA grant agreement n° 290110, SONORUS "Urban Sound Planner".

The authors are also grateful to Matthew Eastel and Simon Bannister from Brighton & Hove City Council, as well as all the soundwalk participants.

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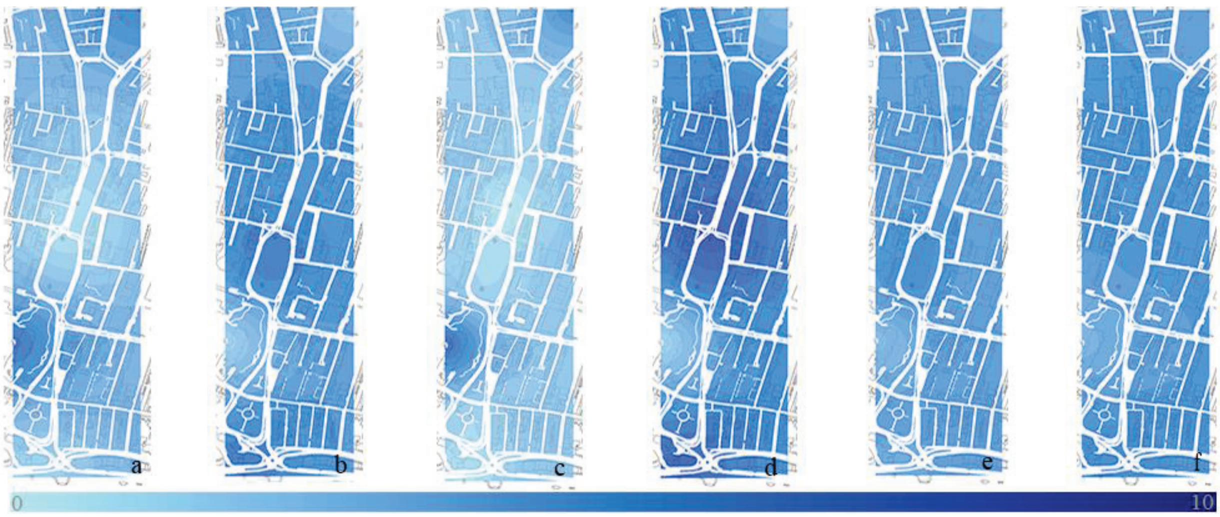

Figure 4. Soundscape appraisal maps: Pleasant (a), Chaotic (b), Calm (c), Annoying (d), Eventful (e), Monotonous (f)

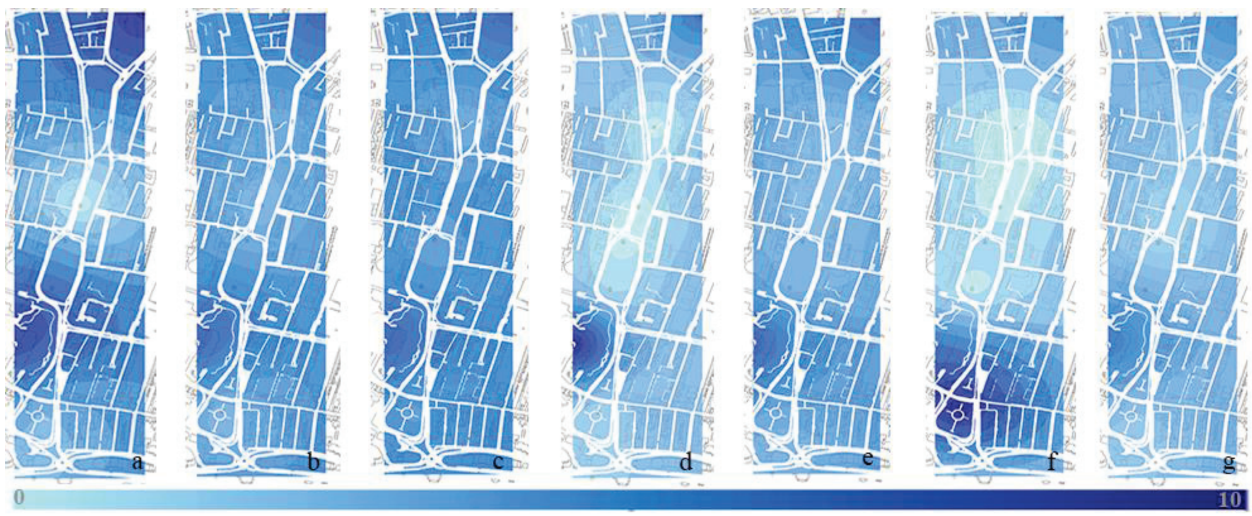

Figure 5. Social and recreational activities maps: Outdoor informal games (a), Walking and running (b), Outdoor exercise (c), Escape city stress (d), Socialising (e), Inland water appreciation (f), Picnic (g)