

The effect of lightscape on soundscape perception in historical sites.

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ABSTRACT

A combined protocol for lightscape and soundscape assessment was tested in four historical locations along Via dei Fori Imperiali (Rome) to identify whether changes in lighting conditions influence the acoustic perception of urban settings with historic value. Objective data were collected at each location while participants filled the questionnaire for both acoustics and lighting. Although acoustic parameters showed little variation between lighting conditions, perceptual changes were observed.

Keywords: soundscape, lightscape, perception

1. INTRODUCTION

The way people experience an environment is affected by external inputs at a physical (e.g., acoustic, visual, thermal) and perceptual (e.g., the feeling of belonging to it, of being happy in it) level at the same time. A main drawback related to the studies conducted so far, especially as far as the physical environmental factors are concerned, is that they are not considered and evaluated in combination. Focusing on the acoustic and lighting domains, much has been done so far, but separately[1]–[5], particularly with the approach of lightwalks and soundwalks to analyse key points or landmarks of the environment quantitatively. However, assessing the acoustic and lighting appropriateness of a place in such a way may fail to recognize the importance of perceptual implications. To this aim, Radicchi & Henckel [6]proposed a method to combines lightwalks and soundwalks for the evaluation of the perception of cities in the night-time. Calleri et al. [7] investigated on the influence of acoustics and lighting on the perception of safety and social presence, which resulted to be improved particularly in presence of background music.

With this shift to a multi-domain approach, a few recent studies [6], [8] explored the use of acoustics and lighting in the environment to the aim of protecting and enhancing the cultural landscape, which is intended as the combination of cultural heritage and territorial context. The perception of cultural landscape in the daytime and in the night-time was shown to be profoundly different. Therefore, this work tests a combined protocol for lightscape and soundscape assessment focusing on the premises of the cultural landscape. A light- and soundwalk was carried out in the area of Colosseum and Fori Imperiali in Rome, where subjects were asked to fill-in a survey on acoustics and lighting perception.

2. METHOD

The study aims to define and test a first draft of a procedure to identify subjective and objective correlation among the acoustic and lighting aspects that influence how people perceive a specific environment. Over the last few years, several studies have demonstrated how the same environment can induce different perceptions if the surrounding conditions change, in terms of sound and light[6].

2.1 Site Description

The Colosseum area was chosen to test the procedure proposed. The site could induce a wide variation of visual sensations, due to its relevance on rich cultural and historical context and its change of surrounding conditions, such as the designed lighting for night-time. This well-known archaeological site is located in the city centre of Rome. It is situated within a restricted traffic zone (Fori Imperiali area) at its southern border.

Figure 1 shows the route followed during the walk and the locations where the measurements were taken for the sound/lightwalk. In the area under investigation and its proximity, traffic is limited to public transport and emergency services, as well as non-motorized vehicles and pedestrians. The locations were visited twice, under day and night conditions from CL2 to Pven. Subsequently, for each location, there are two sets of questionnaires and measurements data available. Only Pven location was investigated at sunset time therefore these data were not included in the analysis.

2.2 Participants

Forty-six students aged between 19 and 52 years ($M=24.9$; $SD=7.2$) voluntarily participated in the study (26 women and 20 men). All participants provided informed consent and research was carried out in

accordance with the ethical requirements approved by BSEER Ethics Committee at University College London (UK).

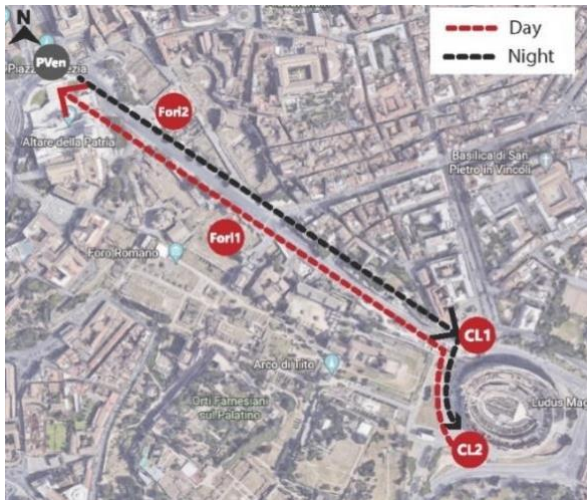


Figure 1- Colosseum archaeological area. Dashed lines show the sound/lightwalk path, red line shows the starting direction (from CL1 to PVen) and the black line the return path (PVen to CL1).

Participants were recruited through an introductory webinar to address the main issues and the whole procedure in a group discussion. During the webinar, key concepts in soundscape and lightscape theory were addressed, as well as the protocol of the walk to be conducted on site. Items of the questionnaire were discussed to have a common understanding of their meaning and provide consistent perceptual data. This approach was already proved to be viable[4].

2.3 Data Collection

The binaural recordings and lighting measurements were carried out in April 2021, between 18:30 and 21:00 hours. Due to the COVID-19 pandemic, there was a lockdown policy in Rome with some restrictions for public activities. However, sound/light walk was still allowed to take place. The sites of the case study are usually quite crowded, but the lockdown implemented at the time of data collection provided an opportunity for a relatively controlled experimental setting less influenced by people's presence. Social presence in a given area has indeed been suggested to affect several perceptual constructs, such as soundscape, visual quality and perceived safety[7], [9], [10].

2.3.1 Questionnaire

The questionnaire protocol was developed based on the instruments from literature, and internal discussion among the authors. Most soundscape-related items were taken from Method A of the ISO/TS 12913-2018 on soundscape [3]. The Soundscape descriptors for the "Historical settings" category were adapted from different sources in literature, with a focus on soundscapes of cultural heritage value [11], [12]. Similarly, the Lightscape descriptors, Light sources and Lightscape

quality categories were adapted from previous sources in literature [1], [7], while the items of Lights for colours and materials category were defined during a workshop session in the context of the project of this study. The questionnaire was translated in Italian before the sound/lightwalk.

2.3.2 Sound and Lighting

During the data collection campaign on site, a non-participant operator performed binaural recordings wearing a head-mounted kit. In order to assess how humans experience the acoustic environment, binaural acoustic measurements (2 mins each) were carried out, as per the Annex D of ISO/TS 12913-2:2018[3], using a Head Acoustics SQobold with BHS II. Simultaneously, photometric measurements were taken at each location at 1.6 m of height (only illuminance was taken at floor level). Participants were guided to the scene where the photometric measurements were taken.

3. RESULTS

The analysis of the data was completed for each location using the total number of responses from participants. Data was grouped by location and by day/night periods. Incomplete data was eliminated from the analysis. The resulting dataset was processed in IBM SPSS Statistics Version 27 (statistical significance at $p < 0.05$). Differences between lighting conditions were tested via Mann-Whitney tests. The lighting analysis of subjective and objective parameters will be reported in separate publications.

3.1 Objective Parameters

The difference (difference=daytime measurement - night-time measurement) of the psychoacoustic objective parameters measured in each location for both lighting conditions (daytime and night-time) did not change significantly over time. If the difference in SPL was around and/or lower than 3 dB, it was considered constant as that difference is usually barely perceptible [13]. The only location which had greater changes in dBA psychoacoustic value was Fori 1 (Δ dBA = 6.43).

3.2 Effects of light on soundscape perception

The aim of the study was to investigate the effect of lighting conditions in soundscape attributes perception at historic locations. Mean values of soundscape descriptors were calculated and used for the statistical analysis. Table 1 shows statistical significance in differences of perceptual soundscape attributes between daytime and night-time for each location.

The "Meaningless" attribute from the proposed historical settings had significant differences in three of the four locations, and also changes are positive meaning that responses tend to change from disagree to agree during night-time as can show in Figure 2.

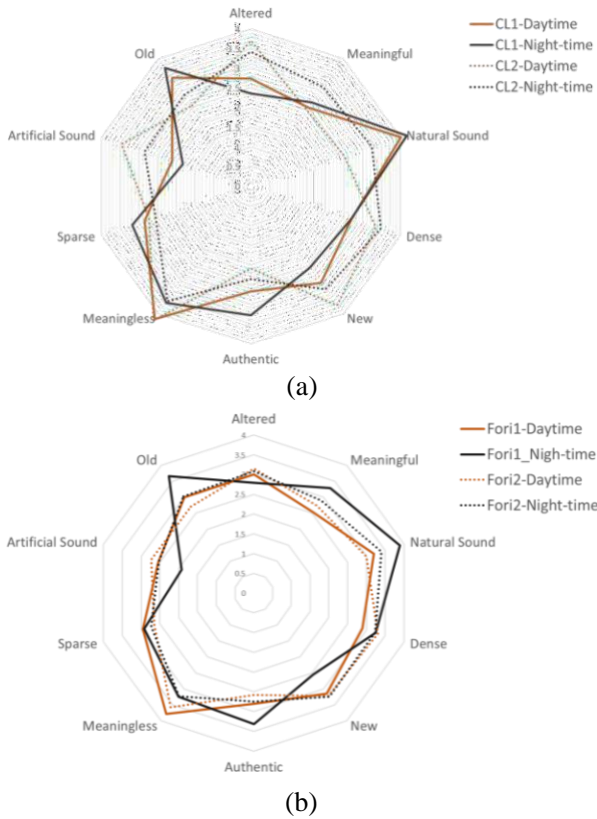


Figure 2. Mean changes in soundscape attributes perception: CL1 (a) and Fori1 (b) are shown in continuous lines; CL2 (a) and Fori2 (b) are shown in dashed lines. Orange lines refer to the daytime while darker lines refer to the night-time.

The distribution of "monotonous" perception scores at CL1 and CL2 between day and night was not similar, as shown in Table 1. For example, scores for CL1-day (mean rank=49.78) were statistically higher than CL1-night (mean rank=38.87), $U = 736$, $z = -2.05$, $p = .040$; while scores for CL2-day (mean rank= 45.64) were higher than CL2-night (mean rank= 33.54), $U = 545.5$, $z = -2.42$, $p = .015$. This may be read to mean that more people thought these two places were more "monotonous" during the day. Similarly, CL1 is considered to be more "meaningless" ($p = .027$), "newer" ($p = .019$), and "altered" ($p = .011$) at night, whereas CL1 is perceived to be more "authentic" ($p = .008$) during the day.

During the day, location CL2 was rated as "calmer" ($p = .008$) and "pleasant" ($p = .001$) than during the night walk. Also, between walks, the counter characteristics "natural" ($p = .008$)-artificial ($p = .028$) and "meaningful" ($p = .008$) -meaningless ($p = .028$) were significantly different, with CL2 being perceived as more artificial and meaningless during the night. Furthermore, Fori1 results revealed more significant variations in most historic attributes. It was perceived as more "authentic" ($p = .050$), having more "natural sound" ($p = .003$), "meaningful" ($p = .003$), and "old" ($p = .030$) during the day, and considerably less "meaningless" ($p = .023$), "new" ($p = .025$), and "artificial sound" ($p = .003$) at night.

Table 1. Mann-Whitney U results of soundscapes attributes between two lighting conditions.

		<i>Mann-Whitney U test</i>			
	Attribute	CL1	CL2	Fori1	Fori2
		p-value			
ISO	Chaotic	0.335	0.082	0.39	0.057
	Annoying	0.827	0.136	0.717	<.05
	Monotonous	<.05	<.05	0.059	0.609
	Uneventful	0.709	0.664	0.236	0.852
	Calm	0.748	<.05	0.074	<.05
	Pleasant	0.249	<.05	0.71	<.05
	Exciting	0.172	0.098	<.05	0.636
	Eventful	0.363	0.216	<.05	0.479
	Historical Settings	Altered	<.05	0.144	0.347
Authentic		<.05	0.185	<.05	0.405
Natural		0.499	<.05	<.05	0.085
Artificial		0.196	<.05	<.05	0.338
Dense		0.979	0.674	0.141	0.791
Sparse		0.065	0.681	0.941	0.58
Meaningful		0.622	<.05	<.05	0.528
Meaningless		<.05	<.05	<.05	0.199
Old		0.368	0.287	<.05	0.184
New	<.05	0.081	<.05	0.804	

4. DISCUSSION

This study evaluated the effects that two lighting conditions have on the perceived soundscapes of historical outdoor spaces along with lightscape attributes. A combined set of methods was used for five different locations in the daytime and in the night-time, where participants were asked to rate their sound and lighting perception while parametric measurements were taken. However, only four locations were analysed since location five was only visited during sunset.

The attribute of "monotonous" was reduced in most locations at night, which could indicate that the lighting in these historical locations modified people's perception of sound to be more dynamic or that people are more aware of their surroundings at night.[14]. The sites in the Colosseum, on the other hand, were viewed as more "meaningless" at night. Overall, we were unable to detect a clear influence of changes in lighting conditions on sound perceptions in our investigation, which supports previous laboratory findings[15]. Although, to the authors' knowledge, past research has merged soundscape and lightscape assessments [9], [14], there is still no consensus on the optimum methodology to utilise, and few methodologies have been used. Also, the attributes proposed for the historical context are yet to be supported and tested in more similar environments; considering that past studies[11] have suggested that historical locations could bring additional meaning and values regardless of the designed surveys.

4.1 Future work

To observe whether lighting conditions have an impact on sound perception, future studies should investigate historical environments in exceptionally differentiating lighting conditions (morning vs evening) and soundscapes conditions. Additionally, would be relevant to test whether perception of historical attributes on both light and soundscape change due to personal experiences and/or background.

5. CONCLUSIONS

A combined sound/lightwalk assessment was carried out in order to test whether different lighting conditions affect sound perception in historical environments. To assess both soundscape and lightscape we created and tested a new instrument, where results showed to be a good first approach to record how people perceive a heritage environment. These preliminary findings draw attention to the relation between sound and light in historical locations as these could not only have an impact on people's experience and perception but understanding the relation between these two could be used during planning stages of the surroundings areas of the historical sites, specifically those located in metropolitan areas.

ACKNOWLEDGEMENTS

The authors thank all the participants who took part in the sound/lightwalk, webinar and workshop as part of this research.

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