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Differences in soundscape appreciation of walking sounds from different footpath materials in urban parks

Francesco Aletta [a], Jian Kang [a,*], Arianna Astolfi [b], Samuele Fuda [b]

[a] School of Architecture, University of Sheffield, Sheffield, United Kingdom
[b] Department of Energy, Politecnico di Torino, Torino, Italy

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ABSTRACT

The perception of the acoustic environment, namely the soundscape, in urban parks has attracted increasing attention. There is a growing belief that the management of the acoustic environment of urban parks should be addressed within a broader soundscape methodology rather than a merely noise control one. One of the most frequent sound sources in urban parks is walking sound; however walking sound perception so far has mainly been investigated for indoor environments. This paper aims to investigate the overall effect of walking sounds from different walked-on materials on people's soundscape, combined with other non-acoustical factors. Moreover, this research investigates how perception varies when the walking sound is self-produced or simply listened. To this purpose, two laboratory experiments in Italy and UK were carried out with four walked-on materials that were considered to be possible design solutions for the footpaths of urban parks: grass, wood, stone and gravel. Results showed a significant effect of materials on perceived noise annoyance and soundscape quality, as well as a partial influence of other non-acoustical factor. Considering the individual responses for the four selected materials, gravel was associated to the worst soundscape quality (M = 38.42) while grass to the best one (M = 65.05). While a group effect (Italian and UK samples) was observed for perceived noise annoyance corresponding to the materials, no significant group effect was found for soundscape evaluation. Eventually, people simply listening to the walking sounds resulted to be less tolerant towards them, with respect to people who self-produced the sounds by walking.

1. Introduction

The Directive 2002/49/EC of the European Parliament and of the Council relating to the Assessment and Management of Environmental Noise (European Parliament and Council, 2002), also known as Environmental Noise Directive (END), requires that the Member States of the European Union define and protect 'quiet areas'. Even though the criteria for identifying such areas are still being discussed, it is generally appreciated that within the city realm such areas tend to coincide with urban parks. Indeed, urban parks represent a vital asset for modern cities and they are therefore receiving increasingly research attention from a wide range of different disciplines like urban planning and design, environmental psychology, sociology, and acoustics (Thompson, 2002; Chiesura, 2004; Yang & Kang, 2005; Brambilla & Maffei, 2006).

There is a growing belief that the management of the acoustic environment of urban parks should be addressed also through a soundscape methodology, rather than an ordinary noise control methodology (Aletta & Kang, 2015). The definition of 'soundscape' has recently been standardised as the "acoustic environment as perceived or experienced and/or understood by a person or people, in context" (International Organization for Standardization, 2014). Thus, there is a clear difference between the acoustic environment (i.e. the physical phenomenon) and the soundscape (i.e. the perceptual construct), and over the years more and more models and methods are being developed to evaluate soundscape (e.g. Aletta, Kang, & Axelsson, 2016; Axelsson, Nilsson, & Berglund, 2010; Axelsson, Lundén, & Nilsson, 2013; Cain, Jennings, & Poxon, 2013). Overall, the noise control and soundscape methodologies have different approaches, but they are complementary: the first considers sound as a 'waste' and emphasises 'discomfort', whilst the latter considers sound as a 'resource' and emphasises 'preference' (Brown, 2012). Both approaches are increasingly integrated and

* Corresponding author at: School of Architecture, University of Sheffield, Western Bank, Arts Tower—S10 2TN Sheffield United Kingdom.
E-mail addresses: f.aletta@sheffield.ac.uk, francesco.aletta@virgilio.it (F. Aletta), j.kang@sheffield.ac.uk (J. Kang), arianna.astolfi@polito.it (A. Astolfi), samuele.fuda@studenti.polito.it (S. Fuda).

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applied together in the broader framework of 'urban sound planning' by researchers (e.g. Alves, Altreuther, & Scheuren, 2014; Alves et al., 2015; Asdrubali, 2014) and local authorities (Lavia, Eastel, Close, Witchel, Axelsson, 2012; Eastel et al., 2014).

Within the soundscape approach it is essential to deal with the nature of sounds (e.g. wanted or unwanted sounds) and great attention should be paid to how all present sound sources interact and are perceived by people in a given context. Considering the acoustic environment of urban parks, this study investigated a particular sound source, namely the walking sound. The access to urban parks is a core value in modern communities (Kornblum, 1978) and the presence of people making a walk looking for calmness, or as a part of their route across the urban realm implies that walking sounds can be a frequent sound source in such contexts, and consequently they can affect their soundscape. Many other sound sources are likely to be experienced in urban parks, corresponding to different activities other than walking (e.g. sport activities, barbecuing), however a larger variety in functions is usually associated to a larger size of the urban park, while walking can be essentially expected for any urban park, regardless of its size (Burgess, Harrison, & Limb, 1988).

1.1. The soundscape of urban parks

Urban parks' soundscapes have been investigated in many studies so far. Brambilla & Maffei (2006) showed that 'expectation' is affecting the noise annoyance perceived in urban parks. More specifically, the more congruent the acoustic environment of the urban parks, the smaller the perceived noise annoyance. In their study, non-natural sounds were found to be inappropriate to the urban parks' context. In other studies by Brambilla and his colleagues (Brambilla, Gallo, & Zambon, 2013; Brambilla, Gallo, Asdrubali, & D'Alessandro, 2013) they showed that some acoustic parameters like the centre of gravity of the unweighted spectrum lg(G) and the 5th percentile N_5 of the loudness could be good predictors of the perceived quality of the acoustics environments of urban parks. However, other researchers reported that many other non-acoustical factors are likely to affect the soundscape of urban parks, like environmental and urban zoning (Margaritis & Kang, 2016), and distance from main routes (e.g. Szeremeta & Zannin, 2009), surrounding context (e.g. Jabben, Weber, & Verheijen, 2015), or specific audio-visual sources (e.g. fountains) in the park (e.g. Axelsson, Nilsson, Hellström, & Lundén, 2015).

Researchers explored the potential 'restorativeness' and 'tranquillity' that the acoustic environments of such places are likely to provide and inspire, considering the positive consequences that they can have for the quality of life improvement (Payne, 2013; Jabben et al., 2015). In terms of psychological restoration from environmental noise, the availability of such green spaces might affect the overall human experience and community life. From the soundscape point of view, it is therefore important to understand what sound sources could help to create a positive acoustic environment and what sources are, conversely, likely to spoil it.

1.2. Walking sounds in the context of urban parks

Walking sounds, i.e. the sounds produced by the footsteps of people walking, have previously been found to be a non-verbal sound with one of the highest ecological frequency (Ballas, 1993). Nonetheless, they received relatively small attention in acoustics and they were mainly investigated for indoor environments (e.g. Johansson, Hammer, & Nilsson, 2004). On the other hand, in outdoor environments, it seems reasonable to assume that walking sounds will achieve frequencies as high as per indoor environments; therefore, further investigation on this specific sound source can be valuable. Within the context of urban parks, if the characteristics of the walkers have to be discarded, the most relevant factor affecting the walking sounds will most likely be the material of the footpaths. The urban parks footpaths' materials might vary largely across countries and cities. The choice of such materials is often a consequence of landscape integration criteria, as well as cost and availability issues. However, it is worth pointing out that different materials will produce different walking sounds, which are in turn likely to result in different soundscapes.

Table 1
Participants samples' composition for Experiments 1 and 2.

Experiment	Group	M_{age}	SD_{age}	M	F	Total
1	University of Sheffield	27.0	4.49	11	14	*25*
	Politecnico di Torino	28.3	8.36	17	21	*38*
2	University of Sheffield	26.9	5.00	10	15	*25*

1.3. Objectives of this research

Considering that the acoustic environment is the result of all sound sources at the receiver in a given context, it is worthwhile questioning to what extent an extremely frequent sound source like walking sound could affect the perception of the acoustic environment, namely the soundscape, in urban parks. The main objectives of this study are:

- Examining whether there is an overall effect of walking sounds from different walked-on materials on people's soundscape.
- Examining whether the above mentioned effect is influenced by a set of non-acoustical factors; namely:
  - People (i.e. different groups of users).
  - Context (i.e. different background noises).
  - Activity (i.e. different listening styles).
- Examining whether the above mentioned effect is changing if people are simply listening to the walking sound or producing it themselves.

To this purpose, two laboratory experiments involving eighty-eight participants in total were carried out with four plausible walked-on materials that were considered to be potential design solutions for the footpaths of urban parks: grass, wood, stone and gravel.

2. Methods

This study, following a previous study (Fuda, Aletta, Kang, & Astolfi, 2015), was designed to test the effect of different footpath materials on individual soundscape assessment of a simulated urban park acoustic environment and to explore potential differences between groups of sitting and walking listeners. Four types of material were considered, with different levels of hardness: grass, wood, stone and gravel. There were two experiments, Experiment 1 and Experiment 2, where the materials were common for both experiments. Therefore they will be reported only once, before describing separately the methods for Experiment 1 and Experiment 2 in detail, in Sections 2.2 and 2.3, respectively. Table 1 summarises the overall participants' samples composition, while more details are provided for both experiments in Sections 2.2.1 and 2.3.1 accordingly.

2.1. Experimental materials and settings

A wooden stage ($2400 \times 600 \times 120$ mm) was constructed and located in the middle of the semi-anechoic chamber of the University of Sheffield. Four materials were selected to cover the platform in turn, as shown in Fig. 1, namely:

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