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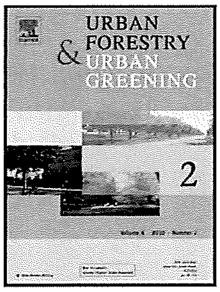

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Soundscape and perceived suitability for recreation in an urban designated quiet zone

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Research highlights:

- The study explored methods to assess soundscape related to suitability for urban recreation.
- Soundwalk better discriminated between noise zones in terms of suitability for recreation.
- The study emphasized importance of quiet zones in urban areas as public health measure.

Green urban parks can offer city dwellers a place to withdraw from traffic noise. However, the significance of the sonic environment for suitability for recreational activities and how to measure this in an appropriate manner, has not been given much research attention. The aim of the study was to investigate the relation between calculated estimates of noise and the soundscape disclosing its suitability for recreation, and to compare three methods of measuring soundscape in an urban park designated as a quiet zone in Oslo. A soundwalk (N=14) and an on-site survey (N=99) were conducted in three different noise zones inside the park, and an off-site survey was conducted outside the park (N=99). The study indicated that the soundwalk method was better at discriminating between the calculated high, medium and low noise zones in terms of the effect on perceived annoyance of traffic noise and suitability for recreational activities and potential for restoration. People outside the park expected the perceived annoyance of the traffic noise inside the park to be higher, and the potential for stress recovery to be lower than those asked in the lowest noise zone inside the park. The study points at the importance of protecting against road traffic noise in urban green areas to facilitate for recreational activities, and brings up pertinent methodological issues for the research on soundscape.

1 Introduction

Recently we have seen a growing interest in the health benefits related to the quality of the outdoor public areas in the city and the experience of urban spaces (Konijnendijk, Annerstedt, Nielsen, & Maruthaveeran, 2013; Payne, 2013). People visit urban green areas for several reasons, such as to experience nature, peace and tranquillity, to socialize, exercise, and spend time with family (Hansen-Møller, Konijnendijk, & Hjorth-Caspersen, 2011). Theories on psychological restoration from fatigue and stress have also emphasized the significance of green urban areas for the possibility to recover (Kaplan & Kaplan, 1989; Ulrich, Simons, Losito, Fiorito, Miles, & Zelson, 1991).

The significance of the sonic environment for usability and suitability for recreational activities has not received much research attention. Numerous studies have been concerned with negative effects of noise for health and well-being, but less research has focused on the total sound landscape and its potential positive effects on restoration and health (Gidlof-Gunnarsson & Ohrstrom, 2010). Andringa and Lanser (2013) propose a cognitive model explaining how pleasant sounds afford audible safety and allows freedom of mind and recreation, while unpleasant sounds can be indicators of threats, which cause an arousing effect impeding recreation. The concept soundscape has been introduced to allow measurement of the quality of the perceived sounds, both positive and negative (Brown, Kang, & Gjestland, 2011; Zhang & Kang, 2007). The International Organization for Standardization (ISO) defines soundscape as “an acoustic environment as perceived or experienced and/or understood by a person or people in context” (ISO, 2014).

Based on a field study in five European countries including 9200 interviews in 14 urban open public places, Yang and Kang (2005) conclude that subjective evaluation of the sound level correlate highly with objective sound measures, especially when the sound level is above a certain level, which was 73 dBA in the referred study. However, the same study reported significant differences between the subjective evaluation of the sound level and preference for the sound in terms of acoustic comfort. The acoustic comfort evaluation was affected by the sound source type, and the introduction of a pleasant sound seemed to improve the acoustic comfort, even when the sound level was high. The lack of correlation between the objectively measured sound level and the preference of the soundscape is supported in other studies (Kang & Zhang, 2010). The same study also found that people generally preferred natural sounds and sounds related to cultural activities rather than artificial sounds. However, older as well as higher educated people tended to prefer natural sounds more than younger and less educated. Younger people also appeared to be more tolerant to mechanical sounds like street music (Kang & Zhang, 2010). Moreover, expectations and indicators of safety seem to guide people's sound perceptions and preferences (Bruce & Davies, 2014; Andringa & Lanser, 2013).

In a summary article from The Positive Soundscape Project, Davies and colleagues (2013) claim that the recent years' research on sound perception in public areas suggests a need for new methods of measuring the soundscape, beyond the traditional ways of measuring sound level and noise. The importance of including contextual factors, such as the type of place and the activity performed there, have been stressed in the development of measures of soundscape (Brown et al., 2011).

To move around in congested cities can be stressful and demands directed attention, creating a state of mental fatigue. Urban parks can be places to withdraw for restoration from states of fatigue and stress for city dwellers, something which is explained in theories on restoration. According to the Attention Restoration Theory (ART) natural environments in the city can provide a physical as well as psychological distance from daily stressors. Exposure to fascinating natural elements may also assist a shift to more effortless attention, which also support restoration from mental fatigue (Kaplan & Kaplan, 1989; Kaplan & Berman, 2010).

Stress Recovery Theory (SRT) (Ulrich et al., 1991) holds that aesthetically pleasing experiences, such as viewing flowerbeds and trees, can decrease physiological activation. Both the ART and SRT are widely used to determine whether the physical environment holds restorative qualities and hence potential health benefits (e.g. Nordh, 2011). The soundscape also plays a role in the restorative process, and audible safety (Andringa & Lanser, 2013) may be a prerequisite for effortless immersion into an outdoor environment. Based on ART and the Perceived Restorativeness Scale (PRS; Hartig, Korpela, Evans, & Gärling, 1997), Payne (2013) developed an instrument to measure restorative qualities of the soundscape (Perceived Restorativeness Soundscape Scale, PRSS). The scale consists of four subscales and was found to differentiate between the soundscape of an urban street environment, an urban park and a natural environment both in a laboratory and a field study. As for the original PRS there was a high correlation between the subscales, with factor analysis showing that the entire instrument loaded high on one factor. So far, no other known studies than Payne (2013) have combined measures of perceived restorativeness of soundscape and suitability for recreational activities in field experiments.

Compared to earlier noise perception research, studying soundscapes involves certain new methodological challenges. The variety of sounds of interest creates the need to assess sounds that are often less pervasive and easier to forget than for instance road traffic noise. Hence, traditional methods such as home surveys that measure residents' general experience of their neighbourhood soundscape, might not be the most suitable approach. Another approach is surveys conducted as on-site interviews of passers-by. The method has the benefit of assessing the perception of the immediate sounds. A challenging aspect of on-site interviews is that they may be time consuming, especially when daily visitors are few. Often, planners are interested in assessing the recreational potential in areas not previously used for recreation, or closed for the general public. In such instances, there might not be *any* daily visitors available. A third approach is group-based soundwalks, which are increasingly applied. Soundwalks are most commonly conducted with various expert-groups, acousticians or architects, but also lay-people are used (Jeon, Hong, & Lee, 2013). Jeon and colleagues (2011) compared use of soundwalks and survey methods. They found that only the results from the soundwalk correlated with the objectively measured sound pressure level. The explanation for this was that only experts participated in the soundwalks, as opposed to lay people that answered the survey. Therefore, in their attempts to develop a framework for improving urban soundscape, Jenning and Cain (2013) argue in favour of conducting soundwalks with comparison of different soundscapes by groups of lay-people.

Despite the stressed importance of including contextual factors of the place in soundscape studies (Brown et al., 2011), few studies examine the relation between the soundscape and the expectation of the potential suitability for recreational activities in the area (Bruce & Davies, 2014). In line with the European Noise Directive, the local authorities in Oslo, Norway, have instigated a program to map the soundscapes of 14 designated Quiet Areas within the city (Bymiljøetaten, 2013). The objective of the present study was to investigate the soundscape in an urban park, one of the designated quiet zones.

The aim of the study was firstly to investigate the relation between objective calculations of noise and both positive and negative aspects of the soundscape disclosing its suitability for recreation or restoration, and secondly, to compare three methods of measuring soundscapes.

2 Methods

2.1 Design

The study compared three methods of linking objective calculations of traffic noise in an urban park to measures of soundscape, in terms of annoyance, as a barrier for recreational activity and its potential for restoration. The three methods included a soundwalk with reports at three predefined sound posts with different levels of traffic noise in the park (within-subjects design), a survey with passers-by inside the park at the same three sound posts, and a survey with passers-by conducted on two sites outside the park (between-subjects designs).

2.2 The study site

In Oslo 14 urban green parks and waterfront landscapes are designated quiet zones according to the European Noise Directive. In Norway the limit is of L_{den} = 50 dB for quiet areas (Bymiljøetaten, 2013; European Commission, 2002). One of these parks, the Palace Park (*Slottsparken*), was chosen as a study site, because of its central location in the city and number of people passing through the park. The park is one of the capital's first established and largest parks, covering a total of 0,23 km^2. It surrounds the Royal Palace on all sides and features grassy areas, mature deciduous trees, ponds, statues and benches. The park was developed in the mid-1800s simultaneously to the construction of the Royal Palace. The park has a slightly complex legal status as it is protected cultural heritage, owned by the state and managed by the Palace gardeners, but is also a part of Oslo city council's planning responsibility (Riksantikvaren, 2015). The park is open to the public with no external fences and is the main thoroughfare for pedestrians from the western part of the city to the city centre. The King's guards patrol the central part of the park. It is a popular site for tourists in summer, and for local inhabitants who use it for recreational activities like picnics and jogging.

2.3 Calculation of traffic noise exposure

Noise exposure in the form of A-weighted equivalent continuous sound pressure levels ($L_{den,}$) from road and rail traffic (tram) was calculated using the Nordic Prediction Method (Nielsen, 1997). The calculations were done as part of Oslo city council's strategic noise mapping and according to European guidelines (European Commission, 2002), based on traffic volumes and topographical input. The method describes noise levels four meters above ground, and is thus not well suited to describe the experience of a typical park user at ground level. Therefore, the calculated noise levels were reference tested by an experienced acoustician, using a noise meter to record short-term sound levels (<2 minutes) at selected spots in the park. Based on a qualitative assessment, the noise estimations were found to be in agreement with the measured levels. The calculated noise levels were categorized into three noise zones; <55dB, 55-65dB and >65dB. One sound post was selected in each of the three zones, based on an assessment of the surrounding areas' suitability for recreational use, as well as possibility to recruit participants (Figure 1.).

---Figure 1---

2.4 Procedure: Soundwalk

The soundwalk was conducted in the end of April, and led by one of the researchers. The air temperature was relatively cold, but normal for the season (10-15 °C) with some showers. The participants were briefly orally informed that they were participating in a study of the environment's potential for recreation and told to walk together through the park and stop several places to fill in a questionnaire. They were also instructed to attend to the sound environment and remain quiet without talking during the walk, which lasted approximately 40 minutes. The participants walked through the three noise zones and stopped on the predefined sound posts within each zone, moving from the quietest zone (1) towards the noisier zones (2 and 3, see Figure 1).

2.5 Procedure: Surveys

The on-site surveys inside the park were conducted during the week after the soundwalk. The air temperature was between 10-15 °C, and the weather was mainly dry. Participants in the survey within the park were recruited among passers-by at each of the sound posts (1, 2, 3) in the park. Passers-by were randomly approached and asked to respond to a questionnaire about their experience and use of the park. Participants in the off-site survey outside the park were recruited at two different sites just outside the park, marked A and B in Figure 1, on the pavement of trafficked streets. The interviewers pointed into the park and provided the instruction 'Imagine that you are inside the park…' and then presented the questions from the questionnaire.

2.6 Participants

Participants in the soundwalk were recruited among Master's students of Public Health Sciences and totally 14 students participated. Both the surveys inside and outside the park had 99 participants. Table 1 describes the demographics of the samples and their score on sensitivity to noise.

---Table 1 ---

2.6 Instruments

The questionnaire covered both positive and negative aspects of the soundscape by including the following instruments. Perceived noise was measured with two items, one covering annoyance with road traffic noise and one item covering annoyance from other sound sources in the specific section of the park. Responses were given on a 5-point scale (1=not annoying, 5=extremely annoying), according to the ISO standardised method for noise annoyance measurement (ISO/TC43 2003).

Perceived restorativeness of the soundscape was measured with five items from the PRSS (Payne, 2013). Perceived *fascination* was measured with "These sounds make me want to linger here". *Being away* was measured with "This sonic environment is a refuge from unwanted distractions" and "When I hear these sounds I feel free from work, routine and responsibility". *Compatibility* was measured with "This sonic environment fits with my personal preferences" and "Hearing these sounds hinders what I would want to do in this place". Responses were given on a 7-point scale (1= totally disagree, 7=totally agree), and the negatively formulated question was reversed in the coding. The items had good internal consistency, with a Cronbach alpha coefficient of .88, based on the results from the survey.

The soundscape as a barrier for recreational activities was measured with six items presented as a scenario where they were encouraged to consider to what extent the soundscape was a barrier for relaxation, walking/strolling, exercising, socializing, reading and appreciating the weather/view/nature. The choice of recreational activities was based on the report by Hansen-Møller and colleagues (2011). Responses were given on a 7-point scale (1=to very little degree, 7=to a large degree). The items covering the soundscape as a barrier for activities had good internal consistency, with a Cronbach alpha coefficient of .90, based on the results from the survey.

Potential for recovery from stress was measured with one item presented as a scenario: "Imagine that you over a period have experienced stress because of life circumstances. You need relaxation and restitution. To what degree would this area be a suitable place?" Responses were given on a 7-point scale (1=to very little degree, 7=to a large degree).

Sensitivity to noise was measured using four items from Weinstein's noise sensitivity scale (Weinstein, 1978). The selected items were, "I am sensitive to noise", "I adapt easily to noise at home", "I need quiet and peace to perform difficult tasks", and "I prefer a park to be quiet over other qualities". Responses were given on a 7-point scale (1= totally disagree, 7=totally agree).

2.7 Statistical analysis

To analyse the soundwalk data, Repeated Measures-ANOVA was conducted to investigate the association between noise zones and how the soundscape was perceived in annoyance (road traffic noise and non-traffic sound), as barrier for recreational activities, and suitability for restoration (perceived restorativeness and potential for stress recovery).

To maximize the difference between the noise zones in the survey data conducted inside the park, they were grouped into two zones: <55 dB and ≥ 55 dB. Since the measure of perceived road noise was skewed, and there was a tendency towards no perceived annoyance connected to noise, it was categorized into "no problems" versus "at least some problem". Binary Logistic regression analysis was used to examine the association between the two sound zones (<55 dB and ≥ 55 dB) and the soundscape's annoyance. Here road traffic noise and non-traffic sound merged. Linear regression was used to examine the association between the two sound zones (<55 dB and ≥ 55 dB) and soundscape as barrier for recreational activities and suitability for restoration, which was perceived restorativeness and potential for stress-recovery. Linear regression was used to estimate the associations between annoyance from road traffic noise and the soundscape as barrier for recreational activity and suitability for restoration, which was perceived restorativeness and potential for stress-recovery.

Linear regression was also used on the data from outside the park to examine relationship between the visual contact with the two sound zones 55-65dB and >65d and the imagined soundscape's annoyance (road traffic noise and non-traffic sound), the soundscape as barrier for recreational activity and suitability for restoration (perceived restorativeness and potential for stress-recovery). In addition, ANCOVA was used to compare all measures of the soundscape between the two groups inside the park and all participants outside the park. SPSS version 22 was applied for all analysis.

3 Results

3.1 Soundwalk

The calculated noise levels corresponded with perceived annoyance of road traffic noise, but not annoyance of non-traffic sound. Additionally, increased level of calculated noise corresponded with the soundscape as a barrier for recreational activities. The calculated levels of noise were negatively related to the perceived restorativeness of the soundscape, as well as the potential for stress-recovery, although marginally significant (p=0.065) (Table 2).

---Table 2---

3.2 Surveys

As in the soundwalk, the calculated levels of noise in the surveys inside the park corresponded with perceived annoyance of road traffic noise, but not annoyance of non-traffic sound. However, there was no relation between calculated level of noise and the soundscape as a barrier to recreational activities. Looking at the positive aspects of the soundscape, there was no relation between calculated level of noise and perceived restorativeness of the soundscape, but a negative, but marginally significant relation with potential for stress recovery (p=0.065) (Table 3).

---Table 3---

On the other hand, there was an association between perceived annoyance from road traffic noise and perceived barrier to recreational activities (B(95% CI) = -0.838(-1.425- -0.251), p=0.006), perceived restorativeness of the soundscape (B(95% CI) = 0.960(0.353-1.568), p=0.002), as well as the potential for stress recovery (B(95% CI) = 0.836(0.043-1.630), p=0.039) (Figure 2).

---Figure 2---

The two off-site surveys showed no differences in any of the measures of the soundscape and were therefore merged into one, before it was compared to the two groups inside the park. ANCOVA showed that the participants outside the park expected the perceived annoyance from road traffic noise inside the park to be higher (M=1.79, SD=0.95) than those who were asked inside the park at the least noisy sound post (*M*=1.41, *SD*=0.84), *F*(2, 188)=3.86, *p*=.023, η_p^2=.039. Those outside the park also expected that being inside the park would offer a lower potential for recovery from stress (*M*=4.07, *SD*=1.90) than the group that was at the least noisy sound post (*M*=4.81, *SD*=1.87). However, this was marginally significant *F*(2, 187)=2.48, *p*=.086, η_p^2=.026). No other differences in the soundscape between those participants interviewed outside and inside the park were detected.

4 Discussion

The study investigated the relationship between objective calculations of noise level and the soundscape in an urban park with the use of three different methods. Both studies conducted inside the park revealed a significant relationship between level of objectively measured sound exposure and perceived annoyance of traffic noise. However, the study indicated that the soundwalk method could better discriminate between the pre-calculated high, medium and low noise zones than the survey, in terms of the soundscapes' suitability for recreational activities and restoration. The survey on the other hand, did only imply a link between perceived annoyance of the traffic noise and the soundscapes' suitability for recreational activities and restoration. Firstly, the findings show the relevance of measuring the soundscape and linking it to peoples' perception of its suitability for everyday recreation. It also emphasizes the importance of protecting against road traffic noise in urban green areas to facilitate for recreational activities and recovery from stress for city dwellers. Furthermore, the findings highlight relevant methodological issues for the research on soundscape.

Overall, the study showed that even with the use of lay-people the soundwalk method provided predictive validity of the soundscape. This is interesting as previous studies using soundwalk methods have used professionals rather that lay people (Jeon et al., 2013). The participants in the soundwalk were instructed to pay attention to the sounds they could hear, but they were not informed about the actual differences in sound levels, which minimizes the possibility of an artificial situation with an accentuated difference among the noise zones. Still it is important to be aware of that a person participating in a soundwalk may be more aware and attentive than normal everyday users. This study also shows that participants inside the park rated themselves as more sensitive to noise than the group outside. Sensitivity to noise, was however controlled for in the statistical analyses. Compared to surveys, soundwalks are advantageous with regard to time and cost efficiency. The disadvantage is that they may be less able to generalize to the population than surveys. This can however be improved by conducting soundwalks with broader user groups, or stratified samples of users.

Previous studies have indicated that visual surroundings can influence the soundscape. In a comparable study of soundscape in green urban parks (Brambilla & Gallo, 2013) it was found that the sound environment in green areas was perceived as good or excellent even though the sound pressure level exceeded the level of that of a defined quiet area. In this study the different sound posts were equivalent in greenness, as well as in suitability for staying or sitting down to take a rest, and the influence of the visual environment can be ruled out as a causal explanation for the results of the soundwalk study.

Furthermore, the study also showed that people interviewed outside the park expected the perceived annoyance of the traffic noise inside the park to be higher. Moreover, they perceived that the potential for stress recovery would be lower than those asked in the lowest noise zone inside the park, also when controlling for familiarity of the park. The people outside the park were stopped on the pavement of congested roads and the finding may be a result of them being influenced by the sonic environment in which they were. This finding is interesting since it would also be reasonable to expect the opposite outcome, which was to rate it as more quiet as a contrast to the busy road. In a previous study Raimbault (2006) found that when passers-by were interviewed on a boulevard they judged the soundscape louder and more disorganised than when people were interviewed in a market place, in which they were more likely to experience the sounds as varied and changing. Hence, the present study demonstrates how one cannot control the impact of the surrounding sonic environment or what people think of when given the task of imagining being in a different place. Therefore, using such a method may have lower predictive validity.

A limitation of the study was its restricted focus on noise from road traffic, and thus further studies should include several noise sources. Future research should continue to investigate the link between soundscape and suitability for recreation by conducting soundwalks.

5 Conclusion

Through combining data from soundwalks, on-site and off-site surveys, the findings of this study suggest that the perception of the soundscape in a large urban park was closely linked to how people perceive its suitability for everyday recreation and restoration. Furthermore, the study's results found that road traffic noise in urban green areas can be a challenge to recreational activities and recovery from stress for city dwellers. Finally, the findings of the study showed that the soundwalk method was better than on-site surveys in discriminating between the pre-calculated high, medium and low noise zones in terms of the effect on perceived annoyance of traffic noise and suitability for recreational activities and potential for restoration. On-site surveys predicted negative aspects of the soundscape better than off-site surveys, stressing the importance of contextual proximity when collecting data to obtain valid environmental assessments.

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Figure 1. Map of the park showing the noise zones and sound posts 1 (<55dB), 2 (55-65dB) and 3 (>65dB), and the sites for the surveys outside the park (A and B).

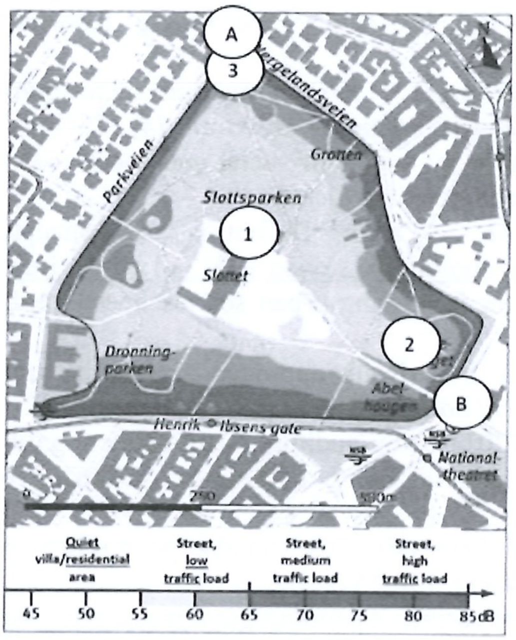

Figure 2. Survey inside park. Means and 95 % CI of the soundscape as a barrier for recreational activity, and perceived restorativeness of the soundscape and the perceived potential for stress recovery as a function of report of perceived traffic noise annoyance.

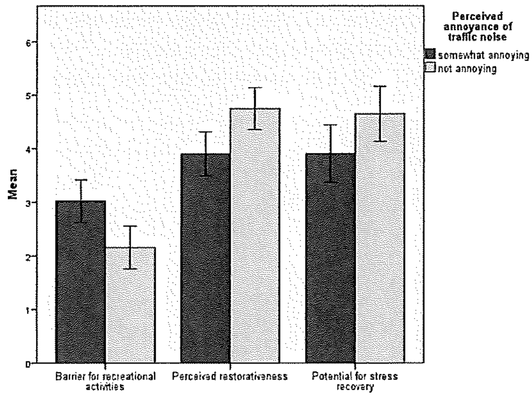

Table 1. Demographic profile of participants and their sensitivity to noise.

		Soundwalk	**Survey**	
			Inside park	**Outside park**
Gender (number (%))	Female	13 (93)	57 (58)	53 (53.5)
	Male	1 (7)	42 (42)	46 (46.5)
Age (mean (range))		32 (21-55)	42 (19-90)	44 (18-80)
Education (number (%))	Primary school		2 (2)	3 (3)
	Secondary school		31 (31)	13 (13)
	University/university college < 4 years		31 (31)	23 (23)
	University/university college ≥ 4 years	14	34 (34)	59 (60)
Occupational status (number (%))	Student	14	26 (26)	14 (14)
	Employed		57 (58)	73 (74)
	Unemployed		6 (6)	3 (3)
	Retired		9 (9)	9 (9)
Sensitivity to noise (1-7) (M(SD))		4.9(0.6)*	4.3(1.3)	4.0(1.4)

*Significant difference in mean score in sensitivity to noise between soundwalk group and group outside park (p=.03).

Table 2. Soundwalk (N=14). RM-ANOVA describing the relation between calculated noise level and negative aspects of the perceived soundscape (annoyance (scales 1-5), barrier for recreational activities (scale 1-7)), positive aspects (perceived restorativeness/potential for stress recovery (scales 1-7)). The variables age and sensitivity to noise are controlled for in the models.

	Calculated noise level					
Soundscape	**<55 dB** *M (SD)*	**55-65 dB** *M (SD)*	**>65 dB** *M (SD)*	**F**	*p*	η_p^2
Negative						
Annoyance						
Road traffic noise	1.71 (0.61)	2.86 (0.86)	3.64 (1.15)	3.42	0.051	0.24
Non-traffic noise	1.50 (0.52)	3.50 (1.34)	1.71 (0.73)	1.21	0.320	0.10
Barrier for recreational activities	3.24 (1.51)	4.21 (1.38)	4.12 (1.72)	6.38	0.007	0.37
Positive						
Perceived restorativeness (PRSS)	4.39 (1.27)	2.57 (1.08)	2.32 (1.06)	7.90	0.003	0.42
Potential for stress recovery	3.79 (1.31)	2.71 (2.02)	1.79 (1.05)	3.10	0.065	0.22

Table 3. Survey inside the park (N=99). Binary logistic regression analysis describing the relation between estimated noise level and perceived soundscape's annoyance, and linear regression analysis describing the relation between estimated noise level and perceived soundscape as barrier for recreational activities (scale 1-7), and positive aspects of perceived soundscape (perceived restorativeness/potential for stress recovery (scales 1-7)). The variables age, gender, education level and sensitivity to noise are included in the models.

	Estimated noise level		
Perceived soundscape	**<55 dB** **M (SD)**	**≥ 55 dB** **M (SD)**	**Effect of sound zone OR (95 % CI)**
Negative			
Annoyance			
Road traffic noise	1.41 (0.84)	1.77 (0.97)	0.212 (0.073-0.614)**
General noise	1.51 (1.06)	1.47 (0.93)	0.992 (0.355-2.773)
			Effect of sound zone B (95 % CI)
Barrier for recreational activities	2.46 (1.65)	2.54 (1.35)	0.105 (-0.517-0.726)
Positive			
Perceived restorativeness (PRSS)	4.69 (1.51)	4.27 (1.43)	-0.437 (-1.081-0.207)
Potential for stress recovery	4.81 (1.87)	4.06 (1.81)	-0.759 (-1.567-0.048)

(**p<0.01)