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Perceptual studies on Landscape and Soundscape in Aachen: Healthy Urban Planning Approach

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ABSTRACT

Over the last 30 years, the World Health Organization has been investigating and promoting initiatives to improve urban health. Therefore, some approaches were developed to seek a better life quality and ensure environmental and sustainable health, like the Healthy Urban Planning approach. This approach is based on the following indicators: healthy lifestyle, social cohesion, housing quality, access to work, accessibility, local food production, safety, equity, air quality & aesthetics, water and sanitation quality, quality of land or mineral resources, and climate stability. In order to verify if these indicators influence landscape and soundscape perception, there were conducted soundwalks in two different areas in the city of Aachen, Germany. Eight measurement spots were selected to collect perception responses, acoustic measurements, GIS data, as well as distance from the receiver, and additional features of urban furniture and facilities. Additionally, this study will investigate if this approach is also suitable for environmental health studies in urban areas with a focus on soundscapes.

Keywords: Landscape, Soundscape, Urban Health

I-INCE Classification of Subject Number: 61

1. INTRODUCTION

According to the World Health Organization (2009), urban planning is shaping human settlements, the health and wellbeing of inhabitants and urban socio-economic conditions. Urban planning can be a central determinant of environmental health, which can enhance urban quality, provide facilities and resources, as well as protect and enhance human health. From this concern, several approaches were developed to seek a better life quality and ensure environmental and sustainable health. Following this concept, Barton and Tsouro (2000) developed a Healthy Urban Planning approach, considering the following indicators: healthy lifestyle, social cohesion, housing quality, access to work, accessibility, local food production, safety, equity, air quality & aesthetics, water and sanitation quality, quality of land or mineral resources, and climate stability.

Regarding the association of landscape and soundscape, several authors have been investigating this topic and some similarities of concepts were found (Thompson, 2002, Brown and Muhar 2004, Pijanowski et al. 2011). According to the European Landscape Convention Agreement (Council of Europe, 2000), “Landscape is an area, perceived by people, whose character is the result of the action and interaction of natural and/or human factors”. Brown et al. (2016) proposes a similar definition of soundscape as “the acoustic environment of a place, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors” (Brown et al. 2016).

In an urban soundscape there is a big diversity of sounds. These sounds can be assessed as desirable and undesirable according to each subject. Noise is considered as an unwanted sound and normally it is associated with traffic. The absence of sounds can also be evaluated as unhealthy, indicating disuse and misuse of urban environments, e.g. when a park is too silent and no one is using the area, it can be considered as an unsafe location for children to play. Looking through this perspective, soundscape studies can also provide indicators of urban health (Lankford, 2009).

The aim of this study is to verify if the indicators proposed in the Healthy Urban Planning approach (Barton and Tsouro 2000) have an influence on location and soundscape perception. It also aims to investigate if the Healthy Urban Planning approach is suitable for environmental health studies in urban areas with a focus on soundscapes.

2. METHODS

2.1 Study Area

The study was conducted in Aachen, a German medium-sized city with a population of approximately 245,000. It is located at the border with Belgium and the Netherlands (Fig. 1).

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Two study areas were selected in or near Aachen’s downtown area: 1) Ludwigsallee: has an area of approximately 23 ha. It is a linear public park situated between avenues, and has a pond and a playground. These sites are all identified with the abbreviation “L” in Figure 1. 2) Adalbertsteinweg with an area of approximately 15.2 Ha. It is a busy street located in a commercial area with an intense traffic of cars and buses, as well as the pedestrians. These sites are referred with the abbreviation “AD”.

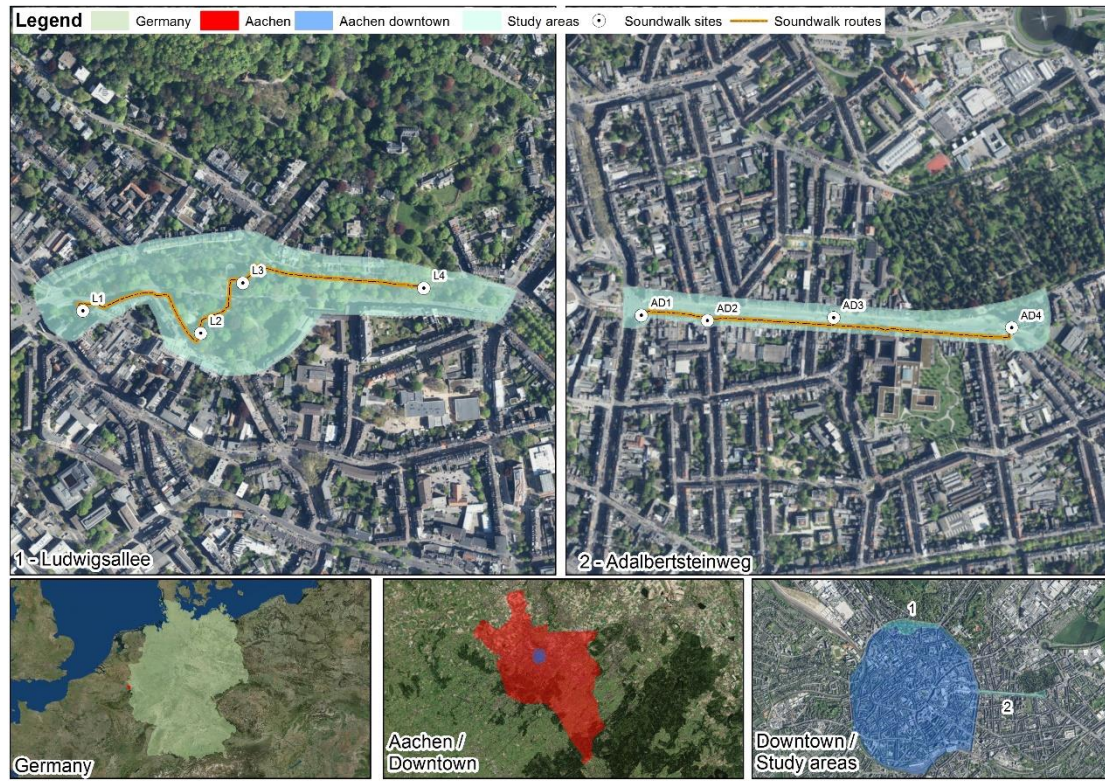


Figure 1 – Study areas

2.2 Data collection

Thirty participants composed of students and academic staff participated in soundwalks in both areas for the subjective data collection. The participants were asked to evaluate the overall environment of three different areas, by answering questions about weather, location and acoustic perception. In this study, only two areas will be analyzed (Ludwigsallee and Adalbertsteinweg). Each area had a total of 90 questions about acoustic and location perception answered by thirty participants. The acoustic questions addressed intensity, comfort, nuisance and welfare recovery. The location questions addressed comfort. All questions presented 6-point scale answer options.

Simultaneously to the questionnaires, the authors conducted sound recordings as well as observations and distance measurements of urban furniture and urban health quality parameters. The sound recordings were post-processed and then calculated means over time from acoustic (SPL and SPLA) and psychoacoustic (Loudness, Sharpness, Roughness, Hearing Model Roughness 1/1 Bark, Hearing Model Roughness 1/2 Bark, Loudness N5, Fluctuation Strength and Tonality) parameters. The observed urban health quality parameters followed the “Healthy Urban Planning approach” parameters (Barton and Tsouro, 2000), and are shown in Tab 1.

Table 1 – Frequency of observed urban health parameters (N=90)

Urban Health Quality Aspect	Urban Health Parameters	Adalbertsteinweg Freq. (%)	Ludwigsalle Freq. (%)
Healthy Lifestyle	Sport courts	-	-
	Sport equipment	-	-
	People practicing sport	-	90 (100)
	Special pedestrian ways	90 (100)	90 (100)
	Special bicycle ways	90 (100)	64 (71,1)
	Mixed pedestrian and bicycle way	-	56 (62,2)
	Playground	-	26 (28,9)
Social Cohesion	Benches	61 (67,8)	90 (100)
	Post boxes	19 (21,1)	-
	Mixed-use place	-	90 (100)
Housing Quality	Graffiti	29 (32,2)	34 (37,8)
	Abandoned Housing	-	-
	Energy Saving Materials	-	-
Access to work	Bus stop	42 (46,7)	26 (28,9)
	Train stop	-	-
	Taxi stands	-	-
Accessibility	Safe walking route	90 (100)	90 (100)
	Safe cycling route	90 (100)	90 (100)
Local Food Production	Market	29 (32,2)	-
	Gardens	-	90 (100)
	Allotment	-	-
	City farms	-	-
Safety	Traffic barriers	42 (46,7)	64 (71,1)
	Streetlamps	90 (100)	90 (100)

	Traffic signs	90 (100)	90 (100)
	Traffic light	90 (100)	90 (100)
	Phone boxes	32 (35,6)	-
	Tempo 20	-	-
	Pedestrian crossing areas	90 (100)	90 (100)
Equity	Students apartments	-	-
Air Quality and Aesthetics	Restriction on Lorries	-	-
	Public sculptures	32 (35,6)	-
	Bollards	90 (100)	90 (100)
	Memorials	-	70 (77,8)
	Energy efficient buildings	29 (32,2)	-
Water and Sanitation	Public lavatories	-	-
	Drinking fountains	-	-
	Waste receptacles	71 (78,9)	78 (86,7)
	Fountains	-	-
	Permeability	29 (32,2)	90 (100)
	Lakes, ponds	-	12 (13,3)
Quality of Land or Mineral Resources	Paths Materials: Concrete	61 (67,8)	26 (28,9)
	Paths Materials: Stone	29 (32,2)	8 (8,9)
	Paths Materials: Gravel	-	56 (62,2)
Climate Stability	Bike renting	-	-
	Car sharing	-	-
	Spots to charge e-cars	-	-

2.3 Statistical Analysis

To verify if the proposed parameters in the Healthy Urban Planning approach have an influence on landscape and soundscape perception, a Principal Component Analysis (PCA) was calculated. The statistical analysis was carried out with the use of IBM SPSS Statistics 22[®]. Before running the PCA, the objective parameters were normalized and means of each urban health quality category were calculated. The list of the analyzed parameters is shown on Tab 2.

Table 2 List of used parameters for the Principal Component Analysis

Aspect	Objective Parameters (OP)	OP Scale	Subjective Parameters (SP)	SP Scale
Landscape - Urban Health Quality	Mean Healthy Lifestyle			
	Mean Social Cohesion			
	Mean Access to Work			
	Mean Accessibility			
	Mean Local Food Production		Location Perception (Comfort)	
	Mean Safety			
	Mean Air Quality and Aesthetics			
	Mean Water and Sanitation			
	Mean Quality of Land or Mineral Resources			
Acoustic	Mean over time Sound Pressure Level (SPL)	Continuous		Ordinal
	Mean over time Sound Pressure Level A-weighted (SPLA)		Sound Perception (Intensity)	
	Mean over time Loudness		Sound Perception (Comfort)	
	Mean over time Sharpness			
	Mean over time Roughness			
	Mean over time Hearing Model Roughness 1/1 Bark		Sound Perception (Nuisance)	
	Mean over time Hearing Model Roughness 1/2 Bark			
	Mean over time Loudness N5		Sound Perception (Welfare Recovery)	
	Mean over time Fluctuation Strength			
Mean over time Tonality				

3. RESULTS AND DISCUSSION

3.1 Communalities from Principal Component Analysis (PCA)

Due to lack of data, Urban Health Quality parameters “Housing Quality”, “Equity” and “Climate Stability” were not considered in the PCA for both areas. For area Adalbertsteinweg, “Social Cohesion”, “Local Food Production” were not used either.

The first scenario (Scenario 1) was simulated using all subjective perception data (acoustic and location) together with acoustic, psychoacoustic and urban health quality parameters. As the “local perception” scores were lower than 0.5 (indicated in bold on Table 3), a second scenario (Scenario 2) was simulated without this parameter.

Table 3 Communalities extracted from the PCA's in Adalbertsteinweg and Ludwigsallee

Parameters	Adalbertsteinweg				Ludwigsallee			
	Scenario 1		Scenario 2		Scenario 1		Scenario 2	
	Initial	Extraction	Initial	Extraction	Initial	Extraction	Initial	Extraction
Location Perception (Comfort)	1,000	0,276	-	-	1,000	0,412	-	-
Soundscape Perception (Intensity)	1,000	0,710	1,000	0,704	1,000	0,829	1,000	0,832
Soundscape Perception (Comfort)	1,000	0,823	1,000	0,822	1,000	0,883	1,000	0,877

Soundscape Perception (Nuisance)	1,000	0,928	1,000	0,928	1,000	0,903	1,000	0,905
Soundscape Perception (Welfare Recovery)	1,000	0,913	1,000	0,913	1,000	0,860	1,000	0,866
Mean Healthy Lifestyle	1,000	0,993	1,000	0,994	1,000	0,974	1,000	0,975
Mean Social Cohesion	-	-	-	-	1,000	0,947	1,000	0,947
Mean Access to work	1,000	0,984	1,000	0,991	1,000	0,939	1,000	0,948
Mean Accessibility	1,000	0,993	1,000	0,996	1,000	0,939	1,000	0,948
Mean Local Food Production	-	-	-	-	1,000	0,970	1,000	0,971
Mean Safety	1,000	0,950	1,000	0,972	1,000	0,955	1,000	0,959
Mean Air Quality and Aesthetics	1,000	0,965	1,000	0,976	1,000	0,909	1,000	0,919
Mean Water and Sanitation	1,000	0,996	1,000	0,997	1,000	0,958	1,000	0,960
Mean Quality of Land or Mineral Resources	1,000	0,996	1,000	0,997	1,000	0,861	1,000	0,860
Mean SPL (normalized)	1,000	0,852	1,000	0,853	1,000	0,906	1,000	0,906
Mean SPLA (normalized)	1,000	0,923	1,000	0,926	1,000	0,909	1,000	0,915
Mean Loudness (normalized)	1,000	0,952	1,000	0,953	1,000	0,986	1,000	0,987
Mean Sharpness (normalized)	1,000	0,862	1,000	0,862	1,000	0,769	1,000	0,765
Mean Roughness (normalized)	1,000	0,944	1,000	0,949	1,000	0,938	1,000	0,941
Mean Hearing Model Roughness 1/1 Bark (normalized)	1,000	0,760	1,000	0,760	1,000	0,932	1,000	0,931
Mean Hearing Model Roughness 1/2 Bark (normalized)	1,000	0,740	1,000	0,739	1,000	0,926	1,000	0,926
Mean Loudness N5 (normalized)	1,000	0,909	1,000	0,911	1,000	0,983	1,000	0,983
Mean Fluctuation Strength (normalized)	1,000	0,591	1,000	0,621	1,000	0,502	1,000	0,499
Mean Tonality (normalized)	1,000	0,747	1,000	0,785	1,000	0,930	1,000	0,941

The results presented on Table 3 will be discussed in the following sections. Only scenario 2 is considered for analysis because it presents the most consistent results.

3.2 Total Variance Explained

It was extracted 5 components in each area. At Adalbertsteinweg, five components explain 88.08% of the variance. At Ludwigsallee, five components explained 90.26% of the variance.

3.3 Component Matrix

Table 4 shows the component matrix from Adalbertsetinweg and Ludwigsallee. The values highlighted in grey show parameters with higher significance (values over 0.5) in each component. Just the components which are composed at least by subjective responses and urban health quality indicators will be analyzed.

In Adalbertsteinweg, the third component loading showed a composition of soundscape subjective parameters (intensity, comfort, nuisance and welfare recovery)

with Urban Health Quality parameters (Healthy Lifestyle and Air Quality and Aesthetics), all positively loaded, pointing out to an overall comfortable and healthy environment.

In Ludwigsallee, the first component loading showed a composition of positively loaded soundscape subjective parameters (intensity, comfort, nuisance and welfare recovery) with Urban Health Quality parameters (positively loaded: Safety, Air Quality and Aesthetics, and negatively loaded: Water and Sanitation and Quality of Land or Mineral Resources), as well as positively loaded acoustic and psychoacoustic parameters (Mean SPL, Mean SPLA, Mean Loudness, Mean Sharpness, Mean Roughness, Mean Hearing Model Roughness 1/1 Bark, Mean Hearing Model Roughness 1/2 Bark, and Mean Loudness N5). This points out to a positive correspondence between subjective soundscape perception and natural indicators of urban health quality, acoustic and psychoacoustic parameters. The third component loading presented all soundscape subjective parameters (intensity, comfort, nuisance and welfare recovery) loading positively, and Urban Health Quality parameters “Healthy Lifestyle” (loading positively) and “Local Food Production” (loading negatively). This points out that even with few “Local Food Production” indicators, there is a positive correspondence of subjective soundscape perception answers and Healthy Lifestyle, due to the promotion of this type of lifestyle in the area.

Table 4 Components Matrix from Adalbertsteinweg and Ludwigsallee

Parameters	Components Adalbertsteinweg					Components Ludwigsallee				
	1	2	3	4	5	1	2	3	4	5
Soundscape Perception (Intensity)	0,246	-0,697	0,292	0,195	0,187	0,524	-0,139	0,531	-0,505	0,051
Soundscape Perception (Comfort)	-0,015	-0,619	0,640	0,171	0,001	0,553	-0,022	0,517	-0,535	-0,128
Soundscape Perception (Nuisance)	0,140	-0,716	0,558	0,291	-0,009	0,498	0,003	0,608	-0,536	-0,011
Soundscape Perception (Welfare Recovery)	0,040	-0,752	0,527	0,262	-0,007	0,508	0,040	0,542	-0,555	-0,072
Mean Healthy Lifestyle	-0,660	0,463	0,556	-0,187	-0,017	-0,314	-0,558	0,577	0,465	0,129
Mean Social Cohesion	-	-	-	-	-	-0,246	-0,924	-0,129	-0,120	-0,047
Mean Access to work	-0,775	0,445	0,121	0,414	0,078	0,130	0,799	0,385	0,335	-0,182
Mean Accessibility	-0,791	0,484	0,282	0,233	0,050	0,130	0,799	0,385	0,335	-0,182
Mean Local Food Production	-	-	-	-	-	-0,046	0,663	-0,534	-0,493	0,030
Mean Safety	0,480	-0,198	0,343	-0,754	-0,126	0,857	-0,203	-0,373	-0,167	-0,127
Mean Air Quality and Aesthetics	-0,261	0,268	0,673	-0,613	-0,090	0,699	-0,261	-0,430	-0,261	-0,329
Mean Water and Sanitation	0,780	-0,492	-0,354	-0,140	-0,036	-0,842	0,199	0,392	0,213	0,109
Mean Quality of Land or Mineral Resources	-0,777	0,492	0,368	0,120	0,033	-0,806	-0,305	0,277	0,137	-0,151
Mean SPL (normalized)	0,876	0,238	0,112	-0,123	0,033	0,934	-0,094	-0,010	0,150	0,050

Mean SPLA (normalized)	0,883	0,330	0,096	0,021	0,167	0,889	-0,133	0,070	0,316	0,054
Mean Loudness (normalized)	0,899	0,337	0,143	0,082	0,057	0,962	-0,022	-0,028	0,219	0,111
Mean Sharpness (normalized)	0,727	0,351	0,094	0,424	-0,151	0,778	0,280	0,032	0,219	-0,177
Mean Roughness (normalized)	0,855	0,344	0,251	0,079	-0,175	0,865	-0,205	0,161	0,345	-0,074
Mean Hearing Model Roughness 1/1 Bark (normalized)	0,731	0,401	0,166	0,191	-0,001	0,900	-0,155	0,004	0,295	0,100
Mean Hearing Model Roughness 1/2 Bark (normalized)	0,698	0,354	0,351	-0,058	-0,011	0,899	-0,148	-0,001	0,291	0,105
Mean Loudness N5 (normalized)	0,838	0,403	0,144	0,162	0,009	0,948	0,028	-0,076	0,129	0,247
Mean Fluctuation Strength (normalized)	0,303	0,092	0,053	0,243	0,677	0,274	0,596	-0,229	0,013	-0,124
Mean Tonality (normalized)	-0,049	0,003	0,020	-0,429	0,774	0,099	0,311	-0,024	-0,229	0,884

4. DISCUSSION

As observed in Table 4, Ludwigsalle presented a greater quantity of components involving subjective soundscape responses and objective parameters related to Urban Health Quality, as well as acoustic and psychoacoustic parameters. The main reason is the higher number parameters related to the urban health quality indicators in this area. This conclusion can be observed in Table 1, which is showing a greater amount and diversity of parameters which are describing each urban health indicator, e.g. “Healthy Lifestyle”, “Safety”, “Local Food Production” and “Waters and Sanitation”.

5. CONCLUSIONS

The main objective of this study was to verify if the indicators proposed in the Healthy Urban Planning approach have an influence on location and soundscape perception, as well as the investigation if this approach is also suitable for environmental health studies in urban areas with a focus on soundscapes.

The results showed some correspondence between soundscape perception data and the Urban Health Quality indicators proposed in the Healthy Urban Planning Approach, as well as acoustic and psychoacoustic data. The highlighted Urban Health Quality Indicators are: “Healthy Lifestyle”, “Air Quality and Aesthetics”, “Safety”, “Water and Sanitation”, “Quality of Land or Mineral Resources” and “Local Food Production”. Those parameters presented a greater significance in the PCA, because they were more frequently observed in each study area and contribute in a positive subjective response to the overall urban environment, affecting also the positive responses regarding to the soundscape perception. “Healthy Lifestyle” was associated to ways to practice sports, enjoyment of leisure time and having a better life quality. “Safety” is an important indicator, which indicates if the activities are intrusive or are leaving the user in an alert

state of mind, reflecting well how the area transmits or not the sense of wellbeing. “Water and Sanitation”, “Quality of Land or Mineral Resources” as well as “Local Food Production” are showing how the areas can be considered sustainable or with a natural aspect. Users have demonstrated in recent studies, the preference of more natural environments, for this reason those parameters can translate well if the Urban Planning is promoting a sense of sustainability to the urban area users’.

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