



# FORUM ACUSTICUM EURONOISE 2025

## COMPARISON OF METHODOLOGICAL APPROACHES FOR INVESTIGATING URBAN PARKS SOUNDSCAPE RESTORATION: A CASE STUDY OF CURITIBA, BRAZIL.

Margret Sibylle Engel<sup>1\*</sup>

Karoline Farias Koloszuki Maciel<sup>2</sup>

Bani Szeremeta<sup>3</sup>

Paulo Henrique Trombetta Zannin<sup>4</sup>

<sup>1</sup> Chair of Acoustics and Haptics, Technische Universität Dresden, Germany

<sup>2</sup> Federal University of Pelotas, Brazil

<sup>3</sup> Paraná State Department of Education, Brazil

<sup>4</sup> Laboratory of Environmental and Industrial Acoustics and Acoustic Comfort, Federal University of Paraná, Brazil

### ABSTRACT

In recent years, numerous studies have emphasized the crucial role of natural sounds in alleviating mental and emotional stress, as well as in restoring cognitive functions. Scientific literature has also underscored the restorative benefits of natural spaces and urban parks, leading to the development of best practice guidelines and legislation for their management. This study aims to compare different methodological approaches for assessing restorative qualities within the soundscapes of urban parks and to track changes over time. For the assessment, two evaluation methods were chosen: Attention Restoration Theory (ART), proposed by Kaplan & Kaplan [1], and the Perceived Restorativeness Soundscape Scale (PRSS), introduced by Payne [2]. The data for this study were collected over two campaigns (2012 and 2021) through interviews with visitors at the Municipal Botanical Garden and Bacacheri Park, both located in Curitiba, Brazil. A Mann-Whitney U test was employed as a statistical analysis to compare non-parametric samples.

**Keywords:** *Soundscape, urban parks, restorative soundscape.*

\*Corresponding author: [margret.engel@mailbox.tu-dresden.de](mailto:margret.engel@mailbox.tu-dresden.de)

**Copyright:** ©2025 Engel et al. This is an open-access article distributed under the terms of the Creative Commons Attribution 3.0 Unported License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

### 1. INTRODUCTION

Since the late 1980s, the importance of restorative environments has been extensively investigated [1]. Kaplan & Kaplan [1] developed the Attention Restoration Theory (ART), which suggests that exposure to natural environments can help restore cognitive resources depleted by mental fatigue. It proposes that directed attention, the mental effort required for tasks such as focusing or problem-solving, can become depleted over time. Natural settings, with their ability to engage effortless attention, promote relaxation and recovery. The theory emphasises the restorative power of environments that offer a sense of fascination, provide a respite from daily stress, and foster a connection to nature, all of which contribute to improved focus, mental clarity, and overall well-being.

Regarding the sonic environment, Payne [2] developed the Perceived Restorative Soundscape Scale (PRSS), based on the ART, a tool designed to measure how different soundscapes (environmental sound environments) contribute to a sense of restoration and well-being. The scale evaluates various aspects of soundscapes, including their ability to promote relaxation, reduce stress, and enhance mental restoration. It focuses on subjective perceptions of sound qualities such as pleasantness, calmness, and naturalness and their impact on a person's emotional and cognitive state. Both methods suggest factors to observe, measure and pursue a restorative effect caused by the environment on humans.





# FORUM ACUSTICUM EURONOISE 2025

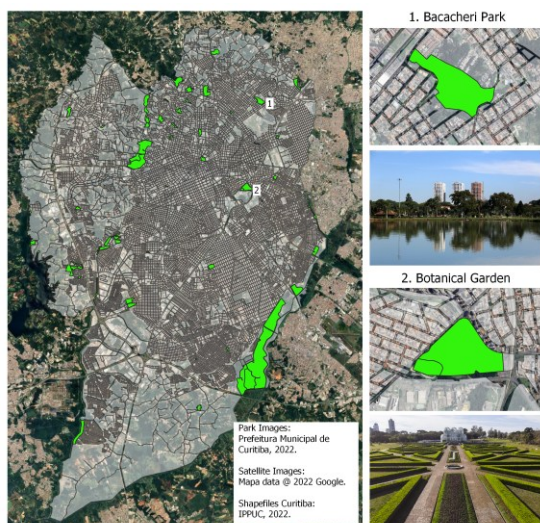
This study aims to evaluate the reliability of these factors, as presented in the proposed theory and tool, as valid perceptual measurement options over time. To achieve this, perceptual data collected from two urban parks in Curitiba, Brazil, will be analysed. With a nine-year gap between data collections, the study will assess the consistency of perceptual instruments, offering a more robust framework for verifying the restorativeness of urban soundscapes over time.

## 2. METHODS

### 2.1 Study Area

The study area comprises two urban parks in the city of Curitiba, southern Brazil. The first area, as indicated in Fig. 1, is Bacacheri Park, located 6 km from Curitiba's city centre, with an area of 152,000 m<sup>2</sup>. The second area is the Botanical Garden of Curitiba, located 2.5 km from the city centre, with an area of 278,000 m<sup>2</sup> [3-4].

As indicated in Szeremeta's PhD thesis [5], the LAeq,15 min had an average of 54.71 dB(A) from measurements of seven spots at Bacacheri Park and 62.88 dB(A) was the average from nine spots in the Botanical Garden during the 2012 survey. The 2021 survey, conducted by Maciel [6], reported an average LAeq of 15 minutes at nine locations, with levels of 54.17 dB(A) in Bacacheri Park and 56.5 dB(A) from sixteen locations in the Botanical Garden.



**Figure 1.** Study Areas

### 2.2 Perceptual survey

The perceptual data of this study consists of the datasets collected by Szeremeta [5] and Maciel [6] through interviews from the same parks, as indicated in the study area, with a temporal difference of nine years. Slight changes in the scales were made over the years. Due to this, it was necessary to recode and fit the scales accordingly, allowing statistical analysis and comparisons. Table 1 outlines the selection of questions that comprise the ART and PRSS set of instruments. The parameters indicated in grey are repeated between the methods.

**Table 1.** Questions and scales

Questions	Year: Scales
Attention Restoration Theory (ART) [1]	
1. Clear mind, or concentration	2021: 1-3 2012: 1-5
Forget Daily Concerns	
2. Mental fatigue recovery	
Allows Reflection	
3. Soft fascination, or interest	
Inspire New Ideas	
4. Reflection and restoration	
Allow Restoration and Relaxation	
Overall Soundscape	
Preserved Nature	
Perceived Restoration Soundscape Scale (PRSS) [2]	
1. Fascination	2021: 1-3 2012 1-5
Inspire New Ideas	
2. Being-Away (-To and -From)	
Forget Daily Concerns	2021: 1-4 2012: 1-6
3. Compatibility	
Soundscape Fits Landscape	
4. Extent Coherent	
Park Sounds As Expected	2021: 1-3 2012: 1-5
5. Extent of Scope	
Human Sounds	
Nature Sounds	

After sorting the data, re-coding, and constructing the matrices, a Kruskal-Wallis test was conducted on the



# FORUM ACUSTICUM EURONOISE 2025

dataset from Bacacheri Park and the Botanical Garden, confirming that the datasets consist of non-normally distributed samples.

The next step was to calculate a Mann-Whitney U test, also known as a Wilcoxon Rank Sum Test, for each set of data using the R statistical package ‘ggstatsplot’ [7]. This package also calculates the effect size of the differences through a r-rank biserial [8].

## 3. RESULTS

### 3.1 Demographics

In the 2012 study by Szeremeta [5], the sample from Bacacheri Park consisted of 48.8% male participants (n = 40) and 51.2% female participants (n = 42). The majority were aged between 18 and 29 years (57.3%). While in the Botanical Garden, the sample consisted of 51.2% males (n = 42) and 48.8% females (n = 40), with an age range of 18 to 29 years (29.3%).

The participants in the 2021 [6] sample from Bacacheri Park consisted of 49% male participants (n = 49), 50% female participants (n = 50), and 1% queer (n = 1). The majority were aged between 18 and 35 years (55%). While in the Botanical Garden, 44% (n = 44) were male and 56% (n = 56) were female, aged between 18 and 35 years (67%).

### 3.2 Mann-Whitney U test results

Before calculating the Mann-Whitney U test for ART and PRSS parameters, a Shapiro-Wilks test was performed to verify whether the data were non-normally distributed. As observed in Table 2, all parameters presented p-values below 0.001, indicating that the data is non-normally distributed, which allows the calculation of Mann-Whitney U tests for non-parametric data.

**Table 2.** Shapiro-Wilk test results for verifying the normality of the data.

Group	Location	Parameter	W	P-value
ART	Bacacheri	Preserved Nature	0.31767	0.000
		Allows Reflection	0.36245	0.000
		Allow Restoration Relaxation	0.31916	0.000
		Inspire	0.41754	0.000

PRSS	Botanical Garden	New Ideas		
		Forget Daily Concerns	0.43284	0.000
		Preserved Nature	0.54611	0.000
		Allows Reflection	0.84287	0.000
		Allow Restoration Relaxation	0.71076	0.000
		Inspire New Ideas	0.71548	0.000
	Bacacheri	Forget Daily Concerns	0.70192	0.000
		Fascination Inspire New Ideas	0.41754	0.000
		Being Away Forget Daily Concerns	0.43284	0.000
		Compatibility Soundscape Fits Landscape	0.51342	0.000
		Extent Coherence Park Sounds As Expected	0.54319	0.000
		Extent Scope Human sounds	0.52108	0.000
PRSS	Botanical Garden	Extent Scope Nature sounds	0.52392	0.000
		Fascination Inspire New Ideas	0.71548	0.000
		Being Away Forget Daily Concerns	0.70192	0.000
		Compatibility Soundscape Fits Landscape	0.63082	0.000
		Extent Coherence Park Sounds As Expected	0.64305	0.000
		Extent Scope Human sounds	0.69266	0.000
PRSS	Botanical Garden	Extent Scope Nature sounds	0.53589	0.000

Table 3 presents the results of the Mann-Whitney U test, comparing the data collected in 2012 and 2021 for Bacacheri Park (BAC) and Botanical Garden (JB) using the ART parameters. Table 4 presents the same statistical analysis for the PRSS parameters. The p-value should be less than 0.05 to be considered statistically significant for differences between the years. The effect size of the changes in the responses can be measured by the r rank



# FORUM ACUSTICUM EURONOISE 2025

biserial measure [8], where  $r < 0.05$  tiny,  $0.05 \leq r < 0.1$  very small,  $0.1 \leq r < 0.2$  small,  $0.2 \leq r < 0.3$  medium,  $0.3 \leq r < 0.4$  large and  $r \geq 0.4$  very large.

As observed in Table 3, the parameters ‘Preserved Nature’ and ‘Allows Reflection’ remained unchanged over the years in Bacacheri Park. However, the other parameters presented changes with different effect sizes. A large effect size is observed in the Botanical Garden for the parameter ‘Forget Daily Concerns’ ( $r = 0.38$ ). In contrast, medium effect sizes were observed for the parameters ‘Allows Restoration Relaxation’ ( $r = 0.29$ ), ‘Allows Reflections’ ( $r = 0.23$ ), and ‘Inspires New Ideas’ ( $r = 0.22$ ). The other parameters exhibit small or negligible effect sizes, indicating that the sonic environment has a more consistent impact on the restorative effects.

**Table 3.** Mann-Whitney U test results for ART parameters for Bacacheri (BAC) and Botanical Garden (JB)

Parameters	W	p-value	r rank biserial	CI95 %	nobs
BAC: Preserved Nature	4083.00	<b>0.92</b>	0.00	[-0.17. 0.16]	182
JB: Preserved Nature	4583.00	0.06	0.12	[-0.05. 0.28]	182
BAC: Allows Reflection	4000.00	<b>0.60</b>	-0.02	[-0.19. 0.14]	182
JB: Allows Reflection	5058.50	0.00	<b>0.23</b>	[0.07. 0.39]	182
BAC: Allows Restoration Relaxation	3907.50	0.27	-0.05	[-0.21. 0.12]	182
JB: Allows Restoration Relaxation	5281.00	0.00	<b>0.29</b>	[0.13. 0.43]	182
BAC: Inspire New Ideas	3612.00	0.02	-0.12	[-0.28. 0.05]	182
JB: Inspire New Ideas	5014.50	0.00	<b>0.22</b>	[0.06. 0.38]	182
BAC: Forget Daily Concerns	3743.00	0.10	-0.09	[-0.25. 0.08]	182
JB: Forget Daily Concerns	5677.00	0.00	<b>0.38</b>	[0.23. 0.52]	182

As observed in Table 4, the results of the Mann-Whitney U test were not significant in the Bacacheri Park for the parameter ‘Extent Coherence Expected Sounds’. In the Botanical Garden (JB), a very large effect size for ‘Extent Scope Human Sounds’ ( $r = -0.46$ ); a large effect size is observed for ‘Being Away Forget Daily Concerns’ ( $r = 0.38$ ) and ‘Compatibility Soundscape – Landscape’ ( $r = 0.30$ ), a medium effect for ‘Fascination Inspire New Ideas’ ( $r = 0.22$ ). In Bacacheri Park, a medium effect size was observed for ‘Extent Scope Nature sounds’ ( $r = -0.26$ ).

**Table 4.** Mann-Whitney U test results for PRSS parameters for Bacacheri (BAC) and Botanical Garden (JB)

Parameters	W	p-value	r rank biserial	CI95%	nobs
BAC: Fascination Inspire New Ideas	3612.00	0.02	-0.12	[-0.28. 0.05]	182
JB: Fascination Inspire New Ideas	5014.50	0.00	<b>0.22</b>	[0.06. 0.38]	182
BAC: Being Away Forget Daily Concerns	3743.00	0.10	-0.09	[-0.25. 0.08]	182
JB: Being Away Forget Daily Concerns	5677.00	0.00	<b>0.38</b>	[0.23. 0.52]	182
BAC: Compatibility Soundscape - Landscape	4854.50	0.00	0.18	[0.02. 0.34]	182
JB: Compatibility Soundscape – Landscape	5344.00	0.00	<b>0.30</b>	[0.14. 0.45]	182
BAC: Extent Coherence Expected sounds	4287.00	<b>0.48</b>	0.05	[-0.12. 0.21]	182
JB: Extent Coherence Expected sounds	4787.50	0.02	0.17	[2.35e-04. 0.33]	182
BAC: Extent Scope Human sounds	3456.00	0.01	-0.16	[-0.32. 0.01]	182
JB: Extent Scope Human sounds	2206.00	0.00	<b>-0.46</b>	[-0.58. -0.32]	182
BAC: Extent Scope Nature sounds	3050.00	0.00	<b>-0.26</b>	[-0.41. -0.09]	182
JB: Extent Scope	3040.00	0.00	-0.26	[-0.41. -	182



# FORUM ACUSTICUM EURONOISE 2025

Nature sounds				0.10]	
---------------	--	--	--	-------	--

<https://www.curitiba.pr.gov.br/conteudo/jardim-botanico-municipal-de-curitiba/287>

## 4. DISCUSSION AND CONCLUSIONS

This study aimed to evaluate the reliability of the restorativeness scales suggested by the ART and PRSS using two data collections, in two urban parks, with a nine-year gap between them.

It is essential to note that the data collection by Maciel [6] took place at the end of the SARS-Cov-2 pandemic, and there are LAeq differences of almost 5 dB(A) in the Botanical Garden compared to the data collected in 2012. This can justify a significant difference in the perception of the sonic environment between the 2012 and 2021 scenarios, especially in the Botanical Garden, which has a more pronounced influence on urban soundscapes compared to Bacacheri Park, which has a more consistent sonic environment.

In contrast, Bacacheri Park demonstrated that almost all suggested perceptual instruments yielded a more consistent response, with a smaller effect size, compared to the measured effects of the Botanical Garden. The parameter of 'Extent Scope: Nature sounds' showed a medium effect size, indicating that this instrument is sensitive to changes in the sonic environment, even if the change was positive, with a decrease in sound levels.

## 5. REFERENCES

- [1] Kaplan, R., and Kaplan, S.. *The experience of nature: A psychological perspective*. Cambridge University Press, 1989.
- [2] Payne, S. R. The production of a perceived restorativeness soundscape scale. *Applied Acoustics*, 74(2), pp. 255-263, 2013.
- [3] Prefeitura Municipal de Curitiba, Parque Bacacheri. 2025. Available in <https://www.curitiba.pr.gov.br/conteudo/parque-bacacheriparque-municipal-gal-ibere-de-matos/291>
- [4] Prefeitura Municipal de Curitiba, Jardim Botânico, 2025. Available in
- [5] Szeremeta, B. A percepção dos praticantes de atividade física sobre a qualidade sonora dos parques públicos de Curitiba. PhD thesis in Physical Education. *Federal University of Paraná*, 2012.
- [6] Maciel, K..F. K. Avaliação da paisagem sonora de parques urbanos por meio da percepção, medição de ruído e mapeamento acústico. Master thesis in Environmental Engineering. *Federal University of Paraná*, 2022.
- [7] Patil, I. Visualizations with statistical details: The 'ggstatsplot' approach. *Journal of Open Source Software*, 6(61), 3167, 2021, doi:10.21105/joss.03167
- [8] Funder, D.C. & Ozer, D.J. Evaluating effect size in psychological research: sense and nonsense. *Advances in Methods and Practices in Psychological Science*, 2019.

