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A Study of Soundscape Restoration in Office-Type Pocket Parks

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Abstract: High-density building environments and fast-paced working conditions in cities pose health challenges for office workers. Office-type pocket parks assume the social responsibility of providing restorative environments for office workers, and the soundscape is an essential element of such environments. However, there is limited research on soundscape restoration in office-type pocket parks. Therefore, this study focused on soundscape restoration in office-type pocket parks. First, on-site investigations explored the spatial characteristics of 55 office-type pocket parks while analysing the soundscape features of 12 representative parks. Notably, significant correlations emerged among the perceptual parameters of the soundscape. Subsequently, three dimensions were extracted through an experimental study on the restoration levels of soundscape elements in office-based pocket parks: attractiveness, coordination, and disengagement. Finally, this study explored the impact of spatial enclosures and interface characteristics on soundscape restoration levels. This revealed that the restorative effect of negative sounds, such as traffic, air-conditioning, and speech, is significantly negatively correlated with spatial enclosure. Therefore, the greater the enclosure, the lower the restorative effect of the soundscape. Birdsongs significantly enhance the attractiveness of grey spaces, whereas small fountain sounds are most coordinated in blue spaces. This study provides a reference for the design of soundscapes in pocket parks to build healthy, restorative urban environments.

Keywords: office-type pocket parks; soundscapes; soundscape restoration

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1. Introduction

Rapid urban development, high-density built environments, and fast-paced working conditions present substantial challenges to office workers' physical and mental well-being [1,2]. "Restorative environments" can alleviate mental fatigue, reduce negative emotions, and promote physiological health recovery [3], which are essential for constructing healthy cities. This has emerged as a research topic in the fields of urban planning, architecture, and environmental psychology. Studies have shown that natural environments are significantly restorative [4,5]. Exploring health restoration in urban public spaces such as parks and green spaces [6,7] confirms that natural urban environments have significant restorative benefits [8,9]. Urban green spaces mitigate stress and fatigue, soothe emotions, and alleviate depression [10,11]. However, the fast-paced working and living conditions in cities result in residents not being able to regularly access the natural environment for leisure, and it is even difficult for them to find the time to reach the green spaces of the urban centre for relaxation. Therefore, urban pocket parks that are close in location to residents should be responsible for providing a restorative environment.

Pocket parks are small-scale public spaces dispersed within urban spatial structures that cater to residents' everyday activities. They exhibit small-scale features, widespread distribution, and convenience and manifest in diverse forms, such as public spaces around single buildings, residential green spaces, street parks, pedestrian greenways, and roof gardens [12]. High-quality pocket parks improve environmental quality and alleviate life and work stress [13], positively impacting mental health and well-being while promoting attention recovery [14]. In addition, the restorative effect of pocket parks is influenced by their spatial features, landscape elements, acoustic environments, and public facilities [15,16]. The number, variety, and colours of natural landscapes are significantly and positively correlated with the stress-relieving effect of pocket parks [17,18].

The World Health Organization (WHO) advocates healthy urban environments to mitigate the adverse effects of noise, assess the soundscape of urban spaces, and encourage the incorporation of soundscape design into urban planning and architectural design processes. The soundscape redirects the attention in environmental acoustics research from considering only negative impacts towards an integrated assessment of the overall effects, considering human perception and utilising sound as a resource to promote healthy and supportive environments [2]. Soundscape restoration facilitates or hinders the effect of the soundscape on restoration in individuals in an environment.

In recent years, the restorative effect of soundscapes of urban spaces has gradually gained attention. Previous studies on soundscape restoration in urban spaces have included evaluation frameworks, influencing factors, soundscape diversity, and audiovisual interactions [19,20]. Studies indicate that premium soundscapes positively impact people's well-being, quality of life, and physical and mental health [21,22]. Natural sounds exhibited significant positive restorations [23,24], whereas traffic and mechanical sounds exhibited significant negative restorations [25,26]. Introducing preferred natural sounds, such as water and birdsongs, into urban spatial environments can mitigate the perceived intensity and interference of noise, such as traffic, and foster a sense of pleasure [27–30]. Soundscapes can significantly enhance the restorative effect of urban public spaces when they coincide with the auditory associations of visual landscapes [31,32]. The spatial enclosure and landscape of parks also influence psychological restoration [33]. Therefore, there is an interaction between pocket park soundscape restoration and factors such as spatial function, spatial morphology, interface characteristics, visual landscape, sound type, and human activities [19,20,31,34].

In 2018, the International Organisation for Standardisation (ISO) published technical specifications for soundscape research and data collection. Soundwalk is used for on-site soundscape perception and audiovisual environment description and has significant advantages in soundscape element perception [35]. Questionnaires and interviews are traditional research methods that are based on sociology and environmental psychology. Studies have been conducted to establish evaluation scales and rating systems, such as the Perceived Restorative Soundscape Scale (PRSS), developed by Payne [20], and the tranquillity evaluation model, proposed by Pheasant [36].

Research on laboratory soundscapes is rapidly growing. Studies have been conducted to evaluate cognitive changes, such as moods, perceptions, behaviours, and emotions, in persons under the influence of soundscapes in anechoic chambers, semi-anechoic chambers, and virtual laboratories [37–40]. Studies have also measured physiological parameters, such as skin conductance levels (SCLs), heart rate (HR), and respiratory rate (RR) [41,42], to comprehensively assess soundscapes' restorative benefits. The experimental data acquisition methods include single-channel recordings, stereo recordings, microphone array recordings, binaural recordings, ambisonic recordings, and portable VR cameras [43–46]. Audio reproduction is typically performed using headphones, monitor speakers, and stereo systems. Visual reproduction uses projection screens, liquid crystal display (LCD) screens, and light-emitting diode monitors. Meanwhile, virtual reality experience technology has gradually become an important method for visual reproduction [47]. Previous soundscape restoration research methods provide bases for future research.

In summary, urban pocket parks are urban microspaces that are an important element for ecological restoration and urban repair. Office-type pocket parks are small-scale outdoor public spaces situated in urban office districts or embedded between office buildings and are closely related to fast-paced, physically and mentally stressed office workers. High-quality soundscape restoration is beneficial for office workers in relieving stress and restoring spirit. However, there is limited research on soundscape restoration in office-type pocket parks. In addition, factors such as the spatial form and visual landscape of a pocket park can directly influence the character of the sound, which, in turn, affects people's perception and evaluation of the sound. Therefore, studying the perceptual characteristics of sounds and soundscapes with different spatial morphologies is important to extend the research scope of spatial acoustics and perception.

Therefore, to improve the restoration provided by urban environments and promote the physical and mental health of office workers, this study investigated soundscape restoration and the factors influencing office-type pocket parks. First, the spatial and soundscape characteristics of the office-type pocket park were investigated using the soundwalk method, and the correlations among the perceptual parameters of the soundscape were analysed. It was concluded that comfort in the acoustic environment is interrelated with the spatial environment, environmental sound pressure level, and type of sound element. Laboratory experiments were conducted to assess the office-type pocket park soundscape restoration and construct restorative dimensions. Finally, the effects of spatial enclosures and visual landscapes on the restorative effect of soundscape dimensions were analysed. This study enriches the soundscape database of office-type pocket parks and provides a basis for pocket park soundscape design and a reference for restorative-oriented urban spatial design that promotes the construction of healthy urban environments.

2. Spatial Characteristics

An on-site investigation was conducted on 55 pocket parks in 10 typical urban office districts, including Jinan Tianfu Software Park, Hanyu Jingu, Chengdu Raffles Square, and the IFS International Finance Centre, to study the spatial characteristics of office-type pocket parks. These pocket parks exhibit diverse spatial, visual, and soundscape types, which can represent the soundscape types of typical pocket parks.

The survey involved determining the geographic locations of the pocket parks using satellite maps and positioning software, measuring the actual sizes of the pocket parks using laser rangefinders, creating plan sketches, and capturing real-life photographs to analyse visual landscape features, thereby establishing a spatial database of office-type pocket parks. For example, the pocket park in Area A of the Tianfu Software Park in Jinan is shown in Figure 1.

Figure 1. Pocket parks in Zone A of Tianfu Software Park.

Office-type pocket parks were classified on the basis of the survey results. They were categorised by plan shape into rectangular, hexagonal, and other shapes and by area into less than 800 m^2, 800 m^2 to 1500 m^2, and more than 1500 m^2. The office building height determined the space height of the pocket park, which was divided into categories of less than 24 m, 24–35 m, 35–100 m, and more than 100 m. Building enclosures are divided into one-, two-, three-, and four-sided enclosures. The bottom interface is divided into greenscape-dominated, waterscape-dominated, and hardscape-dominated interfaces. The proportions of the various office-type pocket parks are shown in Figure 2.

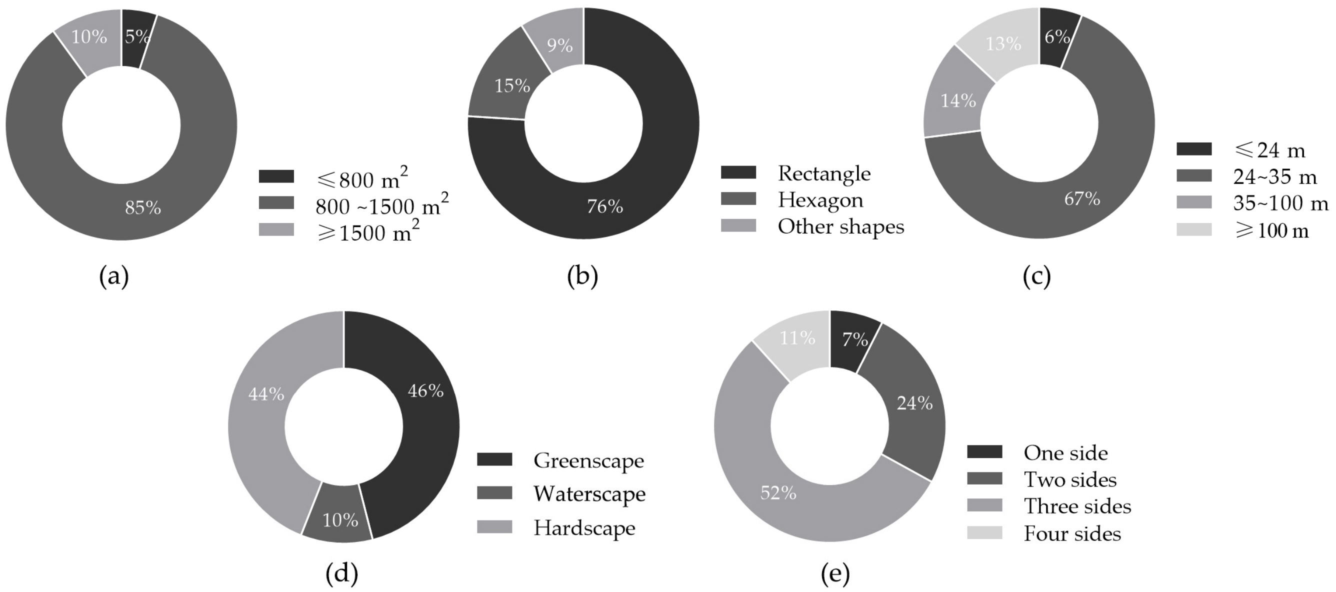


Figure 2. Classifications and proportions of office-type pocket park spaces: (**a**) space area; (**b**) space shape; (**c**) space height; (**d**) ground landscape; (**e**) space enclose.

2.1. Spatial Morphology

This study analysed the scales of the office-type pocket parks. Those between 800 and 1500 m^2 were the most prevalent, constituting approximately 85% of the total. The rectangular spatial morphology was the most common, accounting for approximately 76% of the total morphology. Office-type pocket parks with space heights between 24 and 35 m predominated, composing approximately 67% of the total. Among building enclosures, three-sided enclosures were the most common (52%).

2.2. Spatial Interface

The spatial interfaces of the office-type pocket parks comprised side and bottom interfaces. The side interface denotes the facade of the office building, which is primarily composed of stone, tiles, plaster, and glass windows. The colour was mainly white or light grey. The bottom interface of the pocket park integrates a greenscape, waterscape, and hardscape, complemented by resting seats, fitness facilities, and landscape vignettes. Greenscape dominated in 46% of the pocket parks, followed by hardscape in 44%, while waterscape accounted for 10%.

The spatial morphology and interface characteristics of the office-type pocket parks provided a foundation for an experimental restorative soundscape model.

3. Soundscape Characteristics

On the basis of the initial investigation, 12 typical pocket parks located in office districts—Tianfu Software Park, Innovation Valley, Hanyu Jingu, Raffles Square, and Tianfu Third Street—were selected for soundwalking. The spatial enclosures of the pocket parks include one-, two-, three-, and four-sided enclosures in four forms. The bottom interfaces include the greenscape, waterscape, and hardscape in three forms. Spatial photographs of the pocket parks are shown in Table 1.

Table 1. Photos of the studied typical office-type pocket parks.

Landscape Interface	One-Sided Enclosure	Two-Sided Enclosure	Three-Sided Enclosure	Four-Sided Enclosure
Waterscape				
	11	9	10	7
Greenscape				
	12	2	3	5
Hardscape				
	4	8	1	6

No. 1—Tianfu Software Park A1; No. 2—Tianfu Software Park B2; No. 3—Tianfu Software Park C1; No. 4—Innovation Valley F1; No. 5—Innovation Valley F2; No. 6—Innovation Valley F4; No. 7—Innovation Valley F5; No. 8—Hanyu Jingu G1; No. 9—Hanyu Jingu G3; No. 10—Raffles Square H1; No. 11—Tianfu 3rd Street Garden J1; No. 12—Tianfu 3rd Street Garden J2.

On a sunny weekday in March 2022, 12 graduate students from Shandong Jianzhu University formed a research team to investigate the soundscape data of office-type pocket parks using soundwalking. The survey included measuring the environmental sound pressure level, documenting the composition of soundscape elements, and gathering soundscape perception and evaluation data. Survey photos are shown in Figure 3.

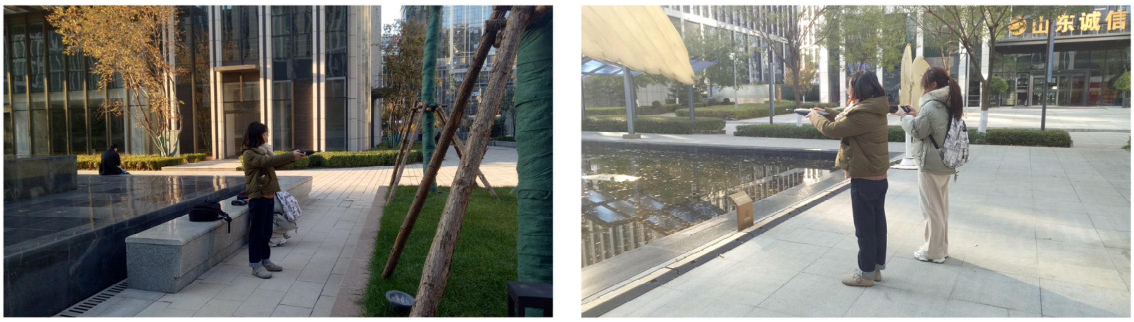


Figure 3. Photos of the on-site investigations.

3.1. Environmental Sound Pressure Levels

To analyse the temporal and spatial variations in environmental sound pressure levels in office-type pocket parks and based on the commuting hours of office workers and the use of the park, the environmental sound pressure levels were measured during four typical periods (7:00–9:00, 11:00–13:00, 14:00–16:00, and 17:00–19:00) using a BK2260 sound-level meter at a height of 1.5 m above the ground, and the duration of each measurement was 15 min.

The environmental sound pressure levels at different times in the office-type pocket parks are shown in Figure 4. It can be seen that the environmental sound pressure levels in the pocket parks ranged from 45 to 73 dBA and varied significantly over time, with the highest levels during the peak commuting hours, while during working hours, most of the parks had lower environmental sound pressure levels. The No. 11 Pocket Park is adjacent to a major traffic artery, and the space is open, with sound pressure levels of up to 73 dBA during commuting hours. Conversely, the No. 6 Pocket Park, located away from traffic arteries and characterised by a high spatial enclosure, maintained lower sound pressure levels, ranging from 45 to 50 dBA throughout the day. An office-type pocket park's location, enclosure, and pedestrian traffic influence the environmental sound pressure levels.

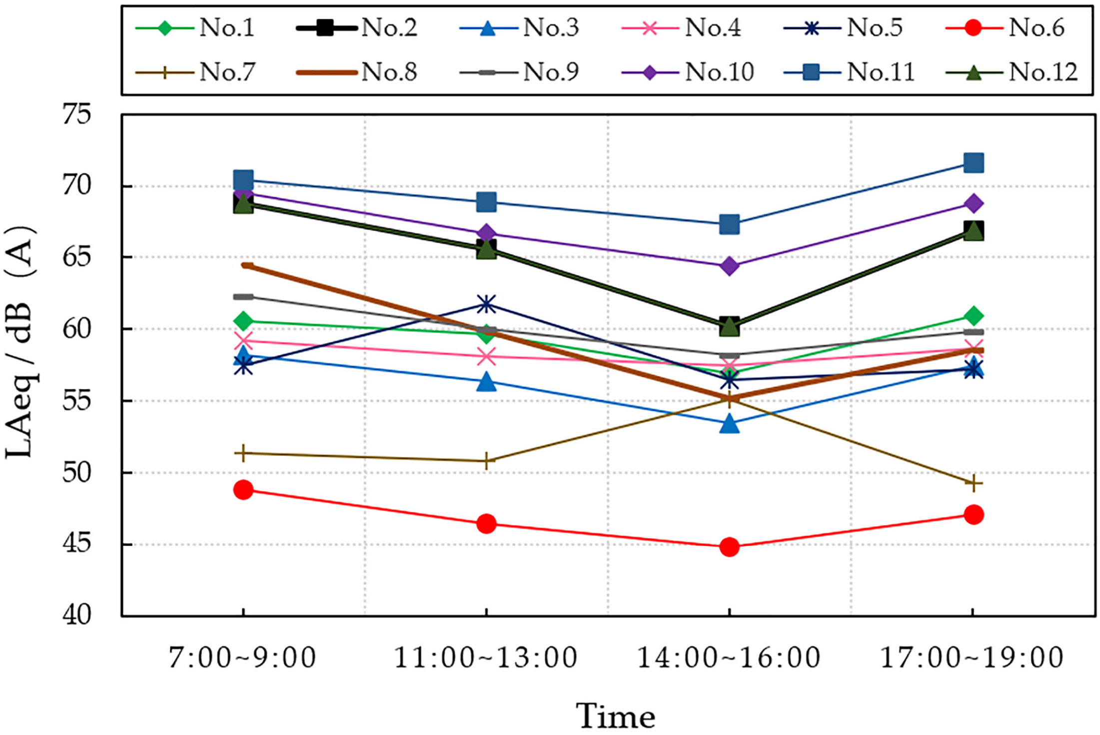


Figure 4. Time variation in the environmental sound pressure levels in each pocket park.

3.2. Composition of Soundscape Elements

Researchers listened to live sounds for 10 min during a pocket park soundwalk and recorded the type of sound source heard. Meanwhile, the researchers evaluated the perceived strength of each sound source using a five-level scale, including "1, 2, 3, 4, 5" points, with the strongest perception being 5 points and the weakest being 1 point. For both, the larger the value, the stronger the perception. The spectra of the typical sound elements and sound level A were measured 1 m from the sound source.

The soundscape elements of the pocket parks mainly encompassed natural sounds, such as birdsongs, fountains, and wind; humanistic sounds, such as speech sounds; and artificial sounds, including traffic, construction, air-conditioning equipment, and music. Traffic sounds occurred in most of the office-type pocket parks. Birdsongs and wind sounds were prominent in spaces dominated by greenscapes, whereas fountain sounds were prominent in spaces dominated by waterscapes. Speech sounds were noticeable during commuting and lunch periods, and the pocket parks in which sound was set up also had music and radio sounds.

The perceived intensities of the soundscape elements in a typical office-type pocket park are shown in Figure 5. The No. 3 pocket park exhibited the highest perceived intensity of birdsongs, while the highest perceived intensities of traffic and air-conditioning equipment sounds were found in the No. 1 pocket park, and the highest perceived intensity of fountain sounds was found in the No. 10 pocket park. The spectra of the six typical sounds commonly found in pocket parks are shown in Figure 6.

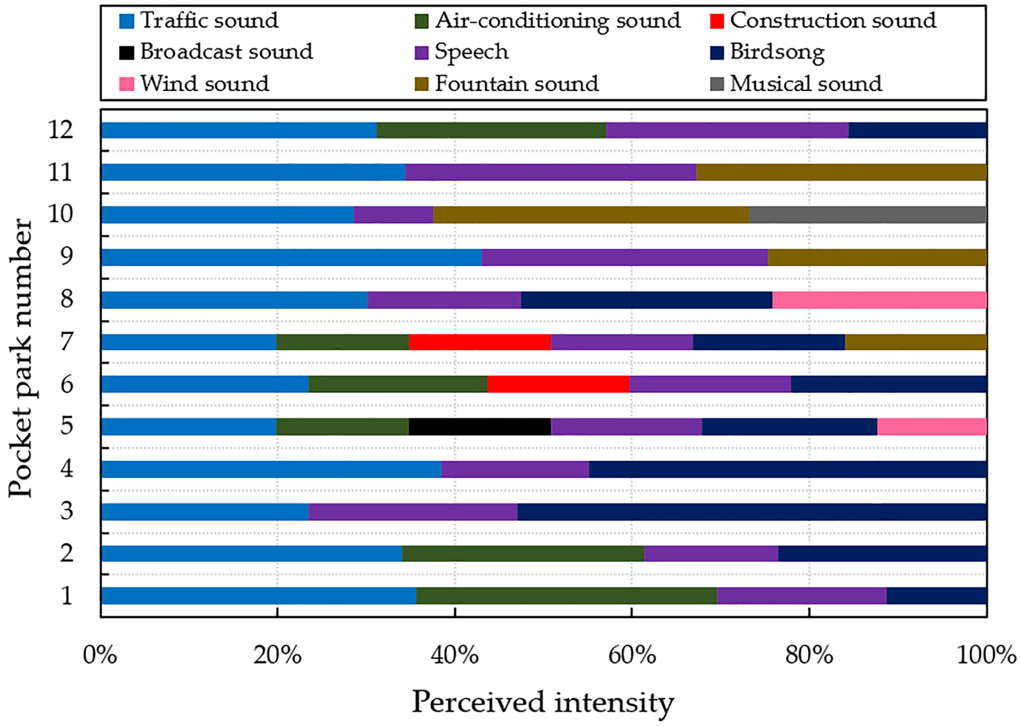


Figure 5. Perceived intensity of soundscape elements in the typical pocket park.

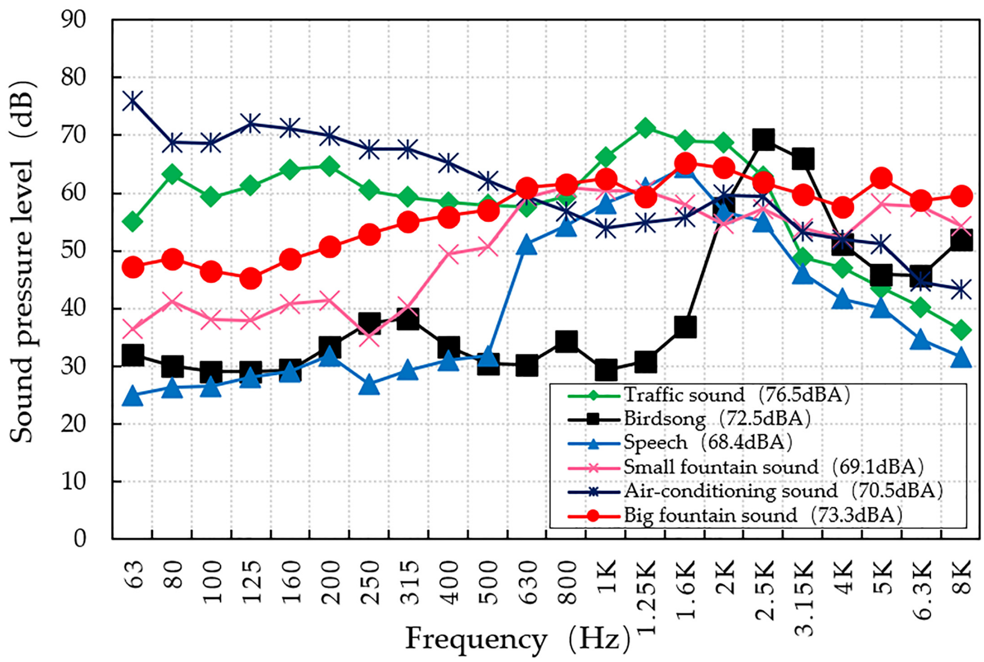


Figure 6. Spectrum of typical sound elements.

3.3. Perception Evaluation of Soundscape

During the soundwalk, the participants completed a soundscape perception questionnaire of the office-type pocket park. The contents of the questionnaire were determined on the basis of previous studies. Parameters such as comfort, naturalness, openness, brightness, tranquillity, and visual landscape preference are commonly used in visual perception evaluation [20,35,48]. Studies have been conducted on the perceptual characteristics of soundscapes in urban parks by selecting parameters such as comfort, variety, naturalness, and coordination [49]. Therefore, on existing studies, this study selected visual landscape comfort (VCD), diversity (VDD), and naturalness (VND) along with acoustic environmental comfort (SCD), diversity (SDD), and naturalness (SND). Additionally, it evaluates the coherence between acoustic and visual landscapes (SVHD). The soundscape perception scale presented in Table 2 uses a 5-level scoring method.

Table 2. Soundscape perception scale.

		Very Much	Comparisons	General	Comparisons	Very Much	
1. Visual landscape comfort (VCD)	Uncomfortable	1	2	3	4	5	Comforts
2. Visual landscape diversity (VDD)	Unitary	1	2	3	4	5	Enrichment
3. Visual landscape naturalness (VND)	Manually	1	2	3	4	5	Naturally
4. Acoustic environment comfort (SCD)	Uncomfortable	1	2	3	4	5	Comforts
5. Acoustic environment diversity (SDD)	Unitary	1	2	3	4	5	Enrichment
6. Acoustic environment naturalness (SND)	Manually	1	2	3	4	5	Naturally
7. Acoustic environment and visual landscape coherence (SVHD)	Incongruity	1	2	3	4	5	Coherence

The Statistical Package for the Social Sciences (SPSS), version 26.0, was employed to assess the reliability of the soundscape perception data for office-type pocket parks, with a Cronbach's alpha of 0.704 ($p < 0.01$). The perception evaluation of the soundscapes of the pocket parks is shown in Figure 7. Park 3 demonstrated high VCD, VDD, SCD, SDD, and SND scores of approximately 4. Conversely, Pocket Park No. 1 received a lower evaluation with a VND score of 2.0, whereas Pocket Park No. 8 exhibited the lowest SCD score of 2.4.

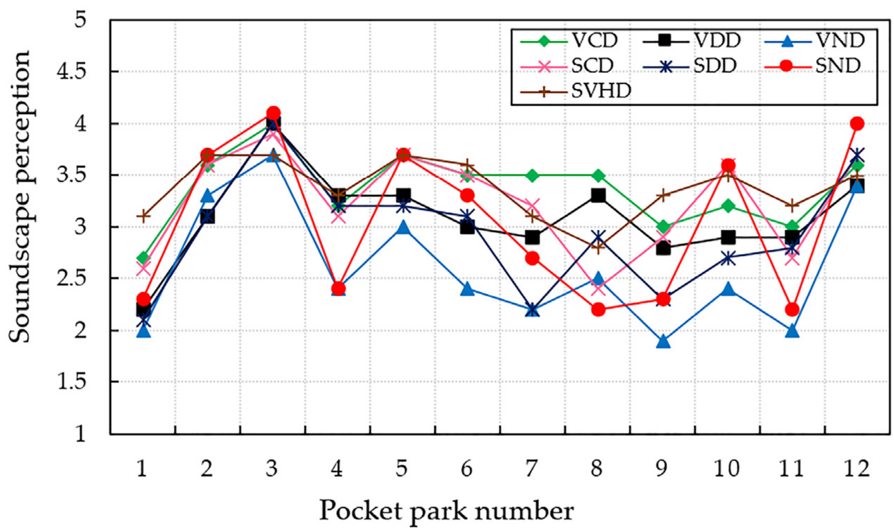


Figure 7. Perception evaluation of the soundscapes in each pocket park.

An analysis of the correlations among the parameters of the soundscapes in the office-type pocket parks revealed a significant positive correlation among the perceived parameters of the soundscape, as shown in Table 3. Notably, the correlation coefficient between SCD and VCD was the most pronounced at 0.594 ($p < 0.01$), indicating that the visual landscape significantly affected soundscape perception.

Although the soundscape perception parameters tended to correlate negatively with environmental sound pressure levels, no statistical significance was observed. Pocket Park No. 3, with a sound pressure level of 58.2 dBA, was higher than most pocket parks and had the highest acoustic environmental comfort score of 3.9. The acoustic environment of this pocket park was dominated by sounds with a high degree of naturalness, such as birdsongs, and it had the highest-rated visual landscape amenity of all pocket parks. Conversely, the sound pressure level of Pocket Park No. 1 was 59.5 dBA, similar to that of Pocket Park No. 3, but this was mainly due to traffic sounds and air-conditioning equipment sounds, scoring only 2.6 in acoustic environmental comfort.

Table 3. Correlation analysis of soundscape parameters.

	VCD	VDD	VND	SCD	SDD	SND	SVHD	SPR
VDD	0.588 **							
VND	0.461 **	0.441 **						
SCD	0.594 **	0.439 **	0.447 **					
SDD	0.474 **	0.517 **	0.471 **	0.491 **				
SND	0.429 **	0.380 **	0.541 **	0.552 **	0.494 **			
SVHD	0.448 **	0.308 **	0.359 **	0.359 **	0.376 **	0.472 **		
SPL	−0.176	−0.458	−0.064	−0.078	0.013	−0.066	0.048	−0.023

** $p < 0.01$.

4. Restorative Soundscape Experiments

Existing office-type pocket parks exhibit diversity and complexity in terms of spatial morphology, scale, and interface but, subsequently, cannot in the form of sequential changes, complicating the analysis of the spatial environment's impact on soundscape restoration. Therefore, this study used survey data to develop spatial experimental models of office-type pocket parks, prepare acoustic signals, and integrate them with spatial morphology. Through restorative soundscape experiments, the independent impacts of each spatial feature factor were studied, and the relationships among them were analysed. A flowchart of the experimental design for the restorative effect of soundscapes of office-type pocket parks is shown in Figure 8.

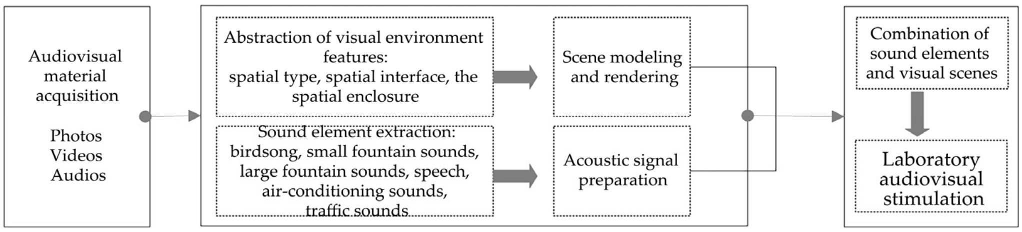


Figure 8. Experimental design for soundscape restoration in office-type pocket parks.

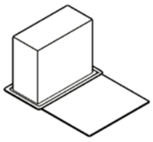
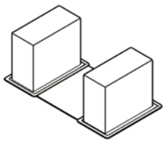
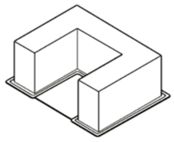
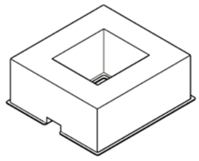
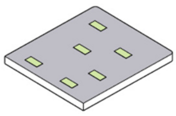
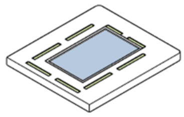
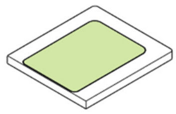
4.1. Materials and Methods

4.1.1. Establishment of Spatial Model

An investigation of existing office-type pocket parks indicated that those spanning an area of 800 to 1500 m^2, with a rectangular plane and a height ranging from 24 to 35 m are predominant. Consequently, a spatial model was established by defining the spatial plane of the pocket park as a 30 × 40 m rectangle. The building, comprising eight stories, features a glass curtain wall and stone veneer interface. The office-type pocket park, an outdoor space adjunct to the office building, was simplified into four forms of enclosure (one-, two-, three-, and four-sided), whereas the bottom interface encompassed a greenscape, waterscape, and hardscape. The spatial abstraction model is presented in Table 4.

Six spatial models were selected and crafted using SketchUp to simplify the experiment, and they were further enhanced by rendering with the D5 renderer to produce 3D scene videos. The rendered scenes are shown in Figure 9. To study the impact of the bottom interface on the soundscape restoration under consistent spatial enclosure conditions, we established a spatial model with the bottom interfaces of a hardscape, greenscape, and waterscape and chose the spatial enclosure to be a three-sided enclosure, as shown in Figure 9a–c. Similarly, to explore the impact of the spatial enclosure under uniform interface conditions, models featuring one-, two-, three-, and four-sided enclosures were established with waterscapes selected for the bottom interface. As shown in Figure 9b,d–f, model (b) was used for the two experiments.

Table 4. Spatial abstract model of office-type pocket parks.

Spatial Feature	Abstract Model			
Spatial enclosure	 (a) One-sided enclosure	 (b) Two-sided enclosure	 (c) Three-sided enclosure	 (d) Four-sided enclosure
Spatial interface	 (a) Hardscape	 (b) Waterscape	 (c) Greenscape	

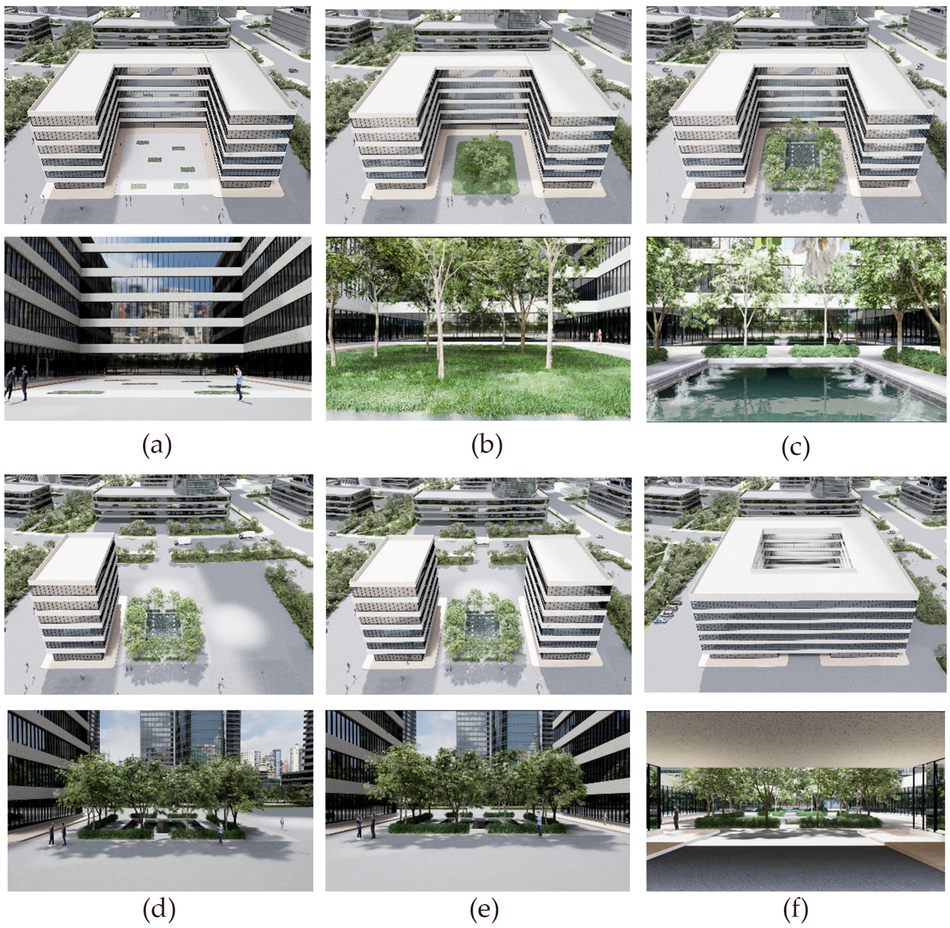


Figure 9. Rendering of the office-type pocket park scenes: (**a**) hardscape with a three-sided enclosure; (**b**) greenscape with a three-sided enclosure; (**c**) waterscape with a three-sided enclosure; (**d**) waterscape with a one-sided enclosure; (**e**) waterscape with a two-sided enclosure; (**f**) waterscape with a four-sided enclosure.

4.1.2. Acoustic Signal Preparation

A Roland high-fidelity recorder was employed to capture the acoustic signals and mitigate potential interference from environmental noise. Six distinct sounds commonly encountered in the pocket park—traffic noise, air-conditioning hum, speech, birdsong, small fountain sounds, and large fountain sounds—were chosen as experimental stimuli. ODEON software facilitated the simulation of reverberation times across various enclosure spaces, whereas Adobe Audition software was utilised to process the experimental acoustic signals to match the acoustic properties of the designated spaces.

Furthermore, to standardise the sound pressure levels and minimise their influence on the experimental results, a BK2260 sound-level meter was used to adjust the sound pressure level of the experimental sound to 55 dBA at the reception point [34]. The pre-experiment demonstrated that participants could complete individual experiments within a 2 min timeframe, prompting the decision to set the playback duration for each experimental sound to 2 min.

4.1.3. Perceived Restorative Soundscape Scale

British scholar Payne developed the Perceived Restorative Soundscape Scale (PRSS) and verified its scientific validity [20]. This scale assesses how soundscapes facilitate or impede recovery from mental and emotional stressors. Researchers have utilised the PRSS to study soundscape restoration [49–52]. The soundscape restorative scale for office-type pocket parks was determined on the basis of existing research and comprised 19 subquestions across dimensions such as fascination, being-away-to, being-away-from, compatibility, and coherency. Participants rated these dimensions on a 5-point scale, allowing for factor analysis, as shown in Table 5. The mean scores derived from each question represented the restorative soundscape of the pocket park, with higher scores indicating superior restoration.

Table 5. Perceived Restorative Soundscape Scale (PRSS) [20].

PRSS	Strongly Disagree	Compare Disagree	General	Compare Agree	Strongly Agree
1. I find this sonic environment appealing	1	2	3	4	5
2. My attention is drawn to many of the interesting sounds here	1	2	3	4	5
3. These sounds make me want to linger here	1	2	3	4	5
4. These sounds make me wonder about things	1	2	3	4	5
5. This sonic environment engrosses me	1	2	3	4	5
6. I hear these sounds when I am doing something different from what I usually do	1	2	3	4	5
7. This is a different sonic environment from what I usually hear	1	2	3	4	5
8. I am hearing sounds that I usually hear	1	2	3	4	5
9. This sonic environment is a refuge from unwanted distractions	1	2	3	4	5
10. When I hear these sounds, I feel free from work, routine, and responsibilities	1	2	3	4	5
11. Listening to these sounds gives me a break from my day-to-day listening experience	1	2	3	4	5
12. These sounds relate to activities I like to do	1	2	3	4	5
13. This sonic environment fits with my personal preferences	1	2	3	4	5
14. I am rapidly getting used to hearing this type of sonic environment	1	2	3	4	5
15. Hearing these sounds hinders what I would want to do in this place	1	2	3	4	5
16. All the sounds I am hearing belong here (with the place shown)	1	2	3	4	5
17. All the sounds merge to form a coherent sonic environment	1	2	3	4	5
18. The sounds I am hearing seem to fit together quite naturally with this place	1	2	3	4	5
19. The sonic environment suggests the size of this place is limitless	1	2	3	4	5

4.1.4. Experimental Procedures

In July 2022, experiments on soundscape restoration in office-type pocket parks were conducted in a semi-anechoic room at Shandong Jianzhu University. An analysis of the sample sizes used in existing laboratory soundscape perception studies revealed larger numbers, such as 246 [53] and 164 [54], smaller numbers of only 10 [55], and that more participants in the experiments were university students [51]. Therefore, in the experiment, to increase the validity of the data, audiovisually normal, physically and mentally healthy university students with some background in architecture were openly recruited. Owing to the limited time available for the study, 167 students were recruited to participate in the experiment. The sample size was more than 5 times the number of questions on the scale and close to 10 times. There were 86 males and 81 females, and the gender distribution was the same, ensuring the homogeneity of the experimental sample. The experiment adopted a "stress-recovery" research paradigm; therefore, the experiment was conducted when students were mentally exhausted after completing a final exam.

In the experiment, the background noise in the semi-anechoic room measured approximately 35 dBA when the projector and lamps were operating and individuals were present. There were eight participants in each group. They sat on a stool approximately 2 m from the screen in a staggered arrangement to ensure that they could see the visual scene and maintain a distance to avoid mutual interference, as shown in Figure 10.

Figure 10. Photo of soundscape restoration experiment.

The researcher distributed the questionnaire, explained the experimental precautions, and instructed the participants to immerse themselves in the scenario while completing the questionnaire. Experimental sounds were delivered through GENELEC dual-channel monitor speakers, and visual scene footage was projected onto a 65-inch screen using an EPSON high-definition digital projector. Each audiovisual signal lasted approximately 2 min with a 1 min rest interval, resulting in a total experimental time of 36 min for each group of 12 signals. Thirty-six audiovisual signal experiments were conducted in three groups, with the audiovisual signals randomised to minimise experimental errors.

4.2. Results and Analysis

4.2.1. Perceived Dimensions of Soundscape Restoration

The collation of restorative soundscape data for all experimental scenarios in office-type pocket parks commenced with the testing of the reliability and validity. Cronbach's α was calculated at 0.907 ($p < 0.001$). The Kaiser–Meyer–Olkin (KMO) measure yielded 0.942 ($p < 0.001$), and Bartlett's test was $\chi 2 = 28,141.165$, which confirmed the suitability of the scale type and sample size for factor analysis.

Factor analysis of experimental data on soundscape restoration for all scenes was performed. Factor principles with eigenvalues greater than one were extracted using the principal component method. Factor loadings of each variable were obtained using the varimax-related method, and items with loadings below 0.7 were excluded, resulting in 18 retained items. The soundscape restorations for the office-type pocket parks were extracted into three dimensions that can clearly describe the original variables. These dimensions contributed 45.95%, 14.21%, and 11.52%, respectively, with a cumulative contribution of 71.68%, as shown in Table 6.

Table 6. Results of soundscape restoration factor analysis (rotated component matrix).

A Priori FACE Components	PRSS Item	Factor 1 (45.95%)	Factor 2 (14.21%)	Factor 3 (11.52%)
Fascination	1	0.864		
	2	0.795		
	3	0.886		
	4	0.765		
	5	0.882		
Being-Away-To	6			0.868
	7			0.858
	8			−0.734
Being-Away-From	9	0.806		
	10	0.892		
	11	0.880		
Compatibility	12	0.828		
	13	0.894		
	14	0.680		
	15	−0.726		
Coherence	16		0.811	
	17		0.836	
	18		0.652	

These three dimensions mirror previous research by Payne on restoration by urban parks and rural soundscapes, with slight variations [20]. Dimension 1 of soundscape restoration for the office-type pocket park included “fascination”, “being-away-from”, and “compatibility”, while Dimension 2 focused on “coherency”, and Dimension 3 emphasises “being-away-to”, as shown in Figure 11.

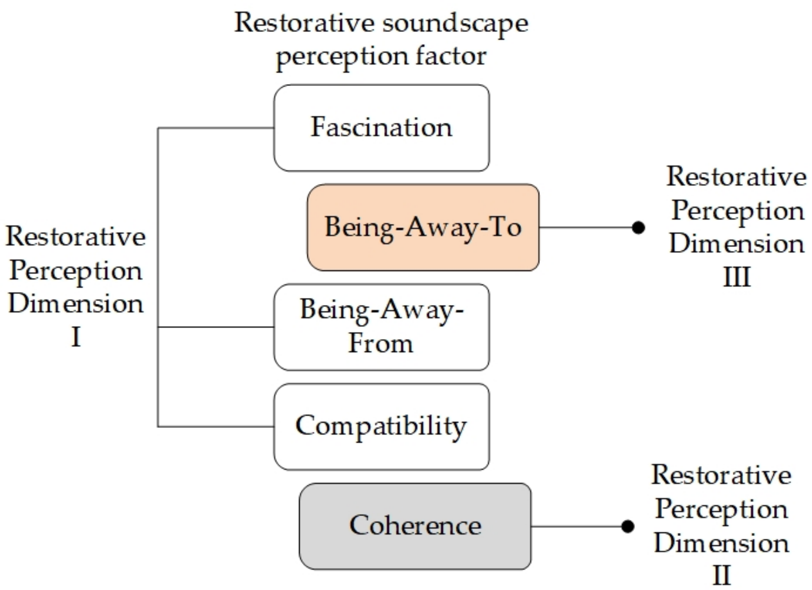


Figure 11. Restorative soundscape dimensions of office-type pocket parks.

The three restorative soundscape dimensions of office-type pocket parks extracted from the experimental study were “attractiveness”, “coordination”, and “disengagement”.

"Attractiveness" signifies the ability of the soundscape to capture attention and integrate it into the environment, fostering a relaxed sense of belonging. "coordination" denotes the harmonisation of sound with the visual environment. High coordination provides a sense of relaxation and harmony and is unique to soundscape restoration. "disengagement" refers to the capacity of the soundscape to transition individuals from a state of exertion and fatigue to a state of relaxation, thus facilitating a restorative experience. While all dimensions are essential, "attractiveness" significantly outweighs "coordination" and "disengagement", emerging as the most critical feature of soundscape restoration in office-type pocket parks.

4.2.2. Restoration Provided by Soundscape Elements

The analysis of restorative soundscape elements based on experimental data from all spaces commenced with the Kolmogorov–Smirnov test to examine the data distribution. The results indicate a departure from the normal distribution. Therefore, the Kruskal–Wallis test was employed to compare the overall restoration provided by the different sound elements. The findings reveal that the restorative effects of birdsong and small fountain sounds were substantial, at 3.89 and 3.56 points, respectively. In contrast, the restoration levels were lower for large fountain sounds (2.95), traffic sounds (2.55), and speech sounds (2.05). Air-conditioning sounds demonstrated minimum restoration at 2.00 points.

Furthermore, to guide restorative soundscape design for office-type pocket parks, this study explored the restorative effect of different sound elements across various environments. The green, blue, and grey spaces denote the greenscape, waterscape, and hardscape, respectively. This study compared the restorative levels of each sound in different environments and analysed discrete cases using boxplot statistics, as shown in Figure 12. Birdsongs exhibited the highest level of restoration at 3.91 points in the green space, with high dispersion in the grey space. Conversely, air-conditioning sounds showed the lowest restoration across the three environments, scoring 2.02 points in the grey space with minimal dispersion.

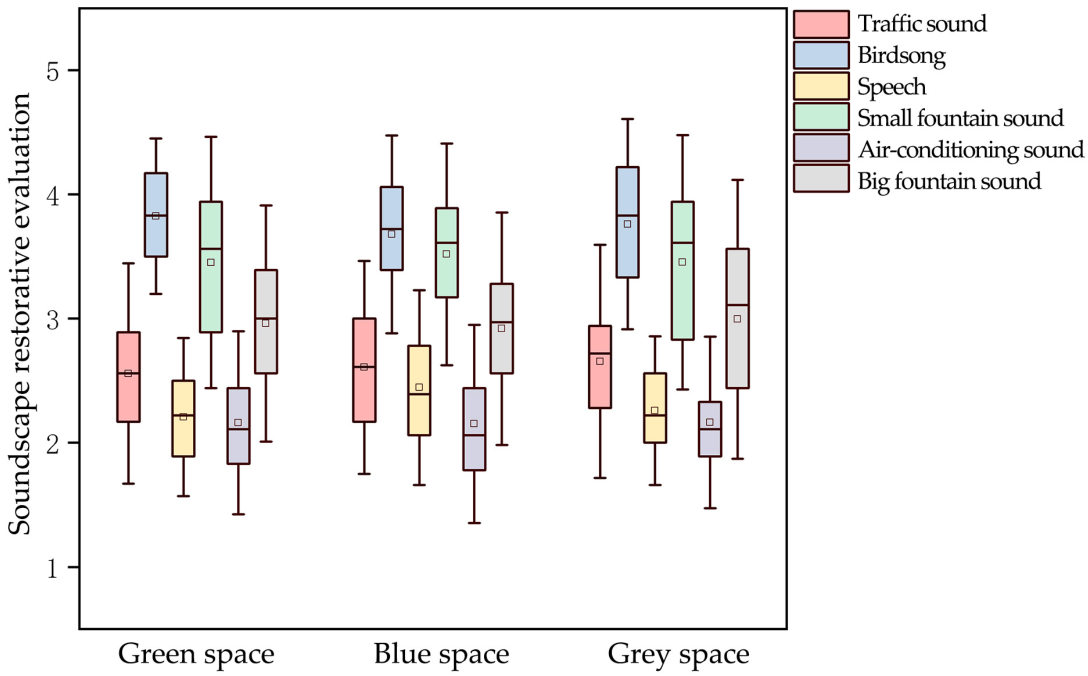


Figure 12. Restoration provided by sound elements in each space.

To further explore the restorative quality of soundscape elements in each space and dimension, a three-dimensional graph was plotted using the X-axis for attractiveness, Y-axis for coordination, and Z-axis for disengagement to visually compare the restorative quality of each sound in different dimensions, as shown in Figure 13. Birdsongs exhibited the highest attractiveness, coordination, and disengagement restoration levels in green and grey spaces. Attractiveness in the grey space was 4.11 points, indicating that birdsongs can enhance the attractiveness of this type of space. In the blue space, the coordination score for the small fountain sounds was 3.61 points, surpassing birdsong, indicating that the fountain harmonises best with the waterscape space. Speech, traffic, and air-conditioning sounds had lower attractiveness, coordination, and disengagement levels in all spaces, with the lowest attractiveness. The attractiveness of air-conditioning sounds in green spaces was only 1.68 points, while speech sounds in grey spaces scored 1.75 points for attractiveness.

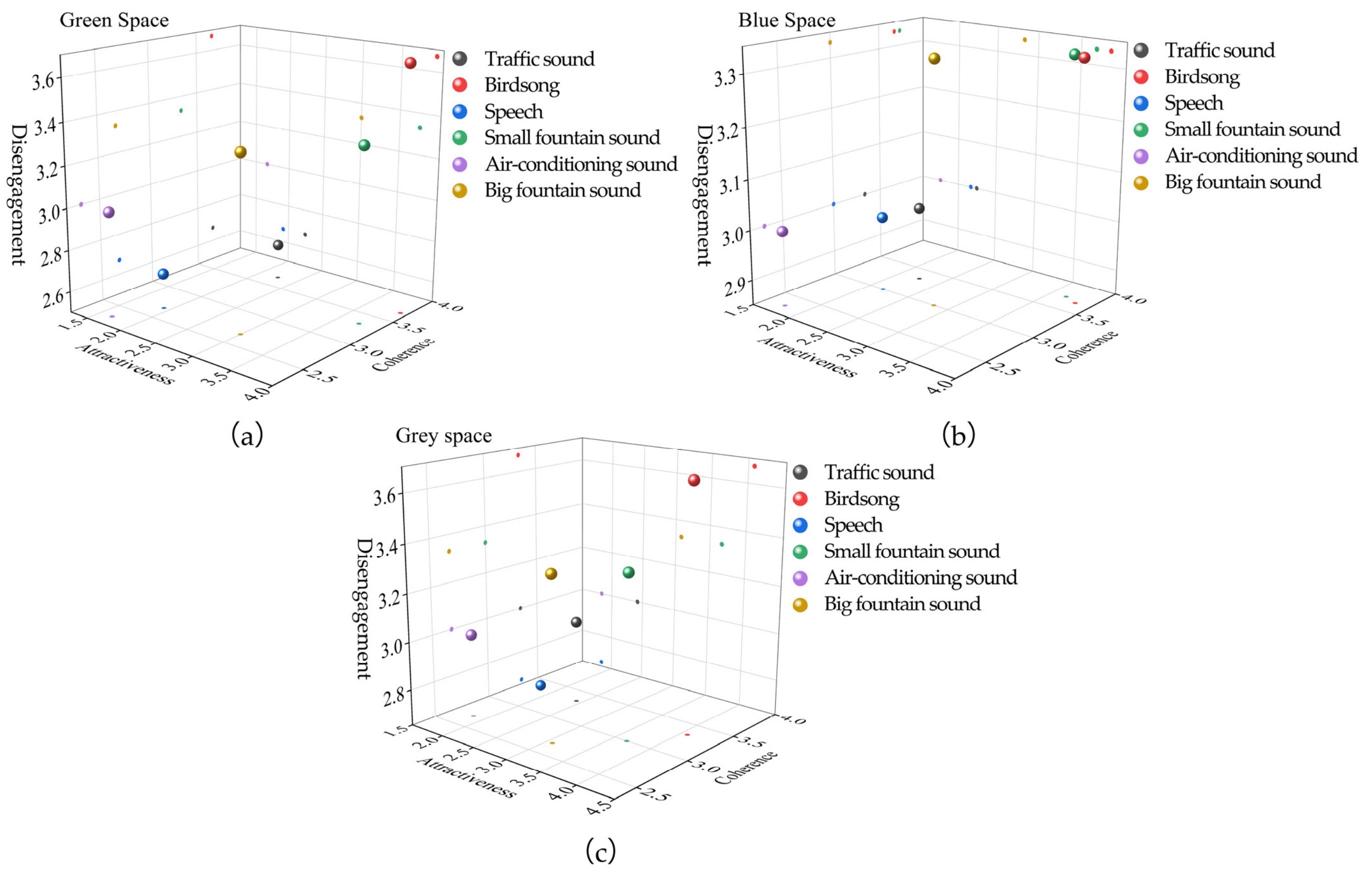


Figure 13. Restoration within each dimension of the soundscape elements in each space: (**a**) green space; (**b**) blue space; (**c**) grey space.

The restorative effect of soundscapes in pocket parks with birdsongs was higher, indicating that natural sounds such as birdsongs coordinate better with greenspace and waterscape environments. The highest restorative evaluations were found for birdsong and fountain sounds in the blue space. However, small fountain sounds had significantly higher coordination evaluation scores than birdsongs. This suggests that fountain sounds are the most harmonious with water-feature-dominated office pocket park environments. In summary, the spatial characteristics of the office-type pocket parks influenced the soundscape restoration. The following section explores the significance of the effects of spatial enclosures and interface materials on soundscape restoration.

4.2.3. Soundscape Restoration and Spatial Characterisation

1. Influence of Spatial Enclosure

The building enclosure of office-type pocket parks influences the spatial reverberation time and the visual environment, impacting acoustic properties and restorative soundscape elements. The bottom interface of the space was designated as a waterscape, and the effects of the four spatial enclosures on soundscape restoration were investigated. These enclosures included one-, two-, three-, and four-sided spaces, as shown in Figure 9c, Figure 9d, Figure 9e, and Figure 9f, respectively.

Spearman's correlation analysis of the restoration effect of each dimension of the sound element with the spatial enclosure, as shown in Table 7, did not indicate any noteworthy correlations between the sounds of birdsongs and fountains and the spatial enclosure. However, the disengagement of air-conditioning sounds exhibited a significant negative correlation with the spatial enclosure, with a correlation coefficient of −0.231 ($p < 0.01$). The attractiveness and coordination levels of traffic sounds were significantly negatively correlated with the enclosure, with correlation coefficients of −0.162 ($p < 0.05$) and −0.326 ($p < 0.01$), respectively. Similarly, the attractiveness and coordination levels of speech sounds also demonstrated a significantly negative correlation with enclosure, with correlation coefficients of −0.318 ($p < 0.01$) and −0.213 ($p < 0.01$), respectively. In office-type pocket parks, the restoration provided by soundscape elements with a positive influence is minimally influenced by spatial enclosures. In contrast, restorative soundscape elements with negative influences showed a significant negative correlation with spatial enclosures. The greater the spatial enclosure, the lower the soundscape restoration level.

Table 7. Correlation between restoration and enclosure of typical soundscape elements.

Sound Elements	Soundscape Perception Restoration Dimension	Spatial Enclosure		
		Correlation Coefficient	Sig.	N
Birdsong	Attractiveness	0.012	0.828	317
	Coordination	−0.38	0.499	317
	Disengagement	−0.030	0.591	317
Small fountain sound	Attractiveness	0.053	0.351	317
	Coordination	−0.051	0.361	317
	Disengagement	0.039	0.486	317
Air-conditioning	Attractiveness	−0.005	0.938	317
	Coordination	0.086	0.217	317
	Disengagement	−0.231 **	0.001	317
Traffic	Attractiveness	−0.162 *	0.020	317
	Coordination	−0.326 **	0.000	317
	Disengagement	0.001	0.994	317
Speech	Attractiveness	−0.318 **	0.000	317
	Coordination	−0.213 **	0.002	317
	Disengagement	−0.106	0.128	317

*, ** Correlations are significant at confidence levels (two-sided) of 0.05 and 0.01, respectively.

2. Influence of Spatial Bottom Interface

This study analysed the relationship between spatial interfaces and the restorative effect of soundscape elements within an identical spatial enclosure. The spatial enclosure of the experimental model was a three-sided enclosure with hardscapes, greenscapes, and waterscapes at the bottom interface, as shown in Figure 8.

The Kruskal–Wallis test was employed to analyse the variances in the restorative effects of soundscape elements in each dimension among the three bottom interfaces. No statistically significant differences were observed in the restoration effect of birdsong, large fountain sounds, air-conditioning sounds, traffic sounds, or speech sounds in each dimension. However, statistically significant variances were identified in the coordination of the small fountain sounds at the three bottom interfaces, with a significance of 0.012.

Further analyses of the coordination of small fountain sounds at different bottom interfaces revealed significant differences between waterscapes and greenscapes and between waterscapes and hardscape environments. The restoration effect of small fountain sounds varied significantly between environments with and without waterscapes. See Table 8. Small fountain sounds exhibited greater coordination in environments with waterscapes, indicating the influence of visual and auditory environmental consistencies on soundscape restoration.

Table 8. Comparison of the results of soundscape restoration with different interface characteristics.

Soundscape Perception Recovery Dimension	Significantly Different Sound Sources	Spatial Interface Characteristics Comparison Group		
		A–B	A–C	B–C
Coordination	Small fountain sounds	0.005 **	0.596	0.023 *

A—greenscapes; B—waterscape; C—hardscape. * $p < 0.05$, ** $p < 0.01$.

5. Discussion

5.1. Effect of Audiovisual Features on Soundscape Perception Parameters

This study analysed the on-site soundscape perception parameters of an office-type pocket park and found significant correlations among the parameters. The positive effect of the visual landscape on the perception of the acoustic environment was significant, and the positive correlation between visual comfort and acoustic environmental comfort was the highest, a finding consistent with previous research [51].

The acoustic environmental comfort of office-type pocket parks is influenced by the spatial environment, soundscape elements, and environmental sound pressure levels. Pocket parks with high levels of acoustic comfort are generally located away from urban roads and are less affected by traffic noise. The landscape is predominantly green with a high degree of visual comfort and naturalness. Pocket parks with low acoustic comfort are dominated by traffic, air-conditioning, and speech sounds. This confirms that natural sounds and environments can contribute to positive perceptual evaluations of space [8–11]. Notably, there was a trend towards a negative correlation between environmental sound pressure levels and each of the perceptual parameters of the soundscape, but no significance was found. This indicates that while pocket parks with lower environmental sound pressure levels generally have a more comfortable acoustic environment; however, this is not always the case. Some pocket parks with higher sound pressure levels had lower acoustic environmental comfort, mainly because the acoustic environment was dominated by traffic and air-conditioning sounds with low visual landscape comfort. However, pocket parks with higher sound pressure levels also have a higher level of acoustic environmental comfort, mainly because the acoustic environment is dominated by natural sounds, such as birdsongs, and there is a higher degree of visual landscape comfort. This illustrates that acoustic environmental comfort is influenced by a combination of sound elements and visual landscape.

On the basis of the above research, it was found that office-type pocket parks with high soundscape perception evaluations need to have the following characteristics: (1) the acoustic environment is dominated by natural sound elements such as birdsong and water sounds. (2) The high naturalness of visual landscapes was dominated by natural landscapes such as grass, trees, and water. (3) The acoustic environment is well coordinated with the visual landscape.

5.2. Soundscape Restoration Dimensions and Influencing Factors

The soundscape restoration experiment for the office-type pocket parks comprised three dimensions: attractiveness, coordination, and disengagement. This soundscape perception structure is similar to but different from Payne's restorative soundscape characterisation for urban parks [20]. Payne categorised urban park soundscape restoration into two major dimensions. Office-type pocket park restoration into three major dimensions (Figure 11). The first dimension of urban parks is composed of "fascination", "being-away-from" and "compatibility", which is consistent with the "attractiveness" dimension of office-type pocket parks. The second dimension of urban parks is made up of "being-away-to", and "coherence", which in the case of office-type pocket parks is divided into the dimensions of "disengagement" and "coordination". The contribution of attractiveness

(45.95%) is much greater than that of coordination (14.21%) and disengagement (11.52%) and is the most dominant restorative characteristic of office-type pocket parks. In addition, the "coordination" of the soundscape, that is, the consistency of the acoustic environment with the visual environment, is a unique restorative feature of the soundscape.

Sound elements influence soundscape restoration in office-type pocket parks. Natural sounds such as birdsongs and fountains were the most restorative sounds [23,24], whereas traffic, speech, and air-conditioning reduced soundscape restoration [25,26], confirming previous findings. Because of the differences in the acoustic parameters of fountain sounds, the soundscape restoration evaluation of small fountain sounds was significantly higher than that of large fountain sounds. In addition, birdsongs enhance the attractiveness, coordination, and disengagement of green and grey spaces and can significantly enhance grey space attractiveness. Birdsong and fountain sounds in the blue space had the highest restorative evaluations, whereas small fountain sounds had the highest coordination. This shows that fountain sounds are most harmonious with office-type pocket parks in which waterscapes are the dominant feature. Therefore, to achieve restorative enhancement, the soundscape design of office-type pocket parks should focus on audiovisual coordination. The introduction of birdsongs into green and grey spaces and the sounds of small fountains in blue spaces can enhance environmental restoration.

Spatial enclosures and spatial bottom interfaces influence soundscape restoration in office-type pocket parks. Spatial enclosures have a negative effect on the restorative effect of negative sounds, such as traffic, air-conditioning, and speech. The higher the spatial enclosure, the lower the restorative effect of negative sounds. The positive sound was less affected by the spatial enclosure. The visual landscape and sound element consistency influence soundscape restoration in pocket parks. The differences in the levels of coordination of small fountain sounds in green spaces, water features, and hard surface spaces were significant; small fountain sounds significantly enhanced the restorative effect of spaces with waterscapes compared with spaces without waterscapes. This finding confirms that harmonising the visual landscape with the auditory landscape in urban spaces significantly improves soundscape restoration [43]. Therefore, restorative soundscape designs for office-type pocket parks with high spatial enclosures should focus on reducing the adverse impacts of negative sounds. Concurrently, restorative soundscape design should also focus on the coordination of landscape and sound so that the soundscape is harmonious and natural.

6. Conclusions

The study investigated the spatial and soundscape characteristics of office-type pocket parks and experimentally explored the perceived dimensions and influencing factors of soundscape restoration. The results show that there was a significant correlation among the parameters of on-site soundscape perception in office-type pocket parks. Acoustic environmental comfort is influenced by the spatial environment, ambient sound pressure level, and sound elements. The experimental study constructed three restorative soundscape dimensions: attractiveness, coordination, and disengagement. Birdsong and fountain sounds were positively restorative, while traffic, air-conditioning, and speech were negatively restorative. Birdsong sounds were the most attractive, coordinated, and disengaging in green and grey spaces and significantly enhanced the attractiveness of grey spaces. Small fountain sounds in blue spaces had the highest coordination. There was a significant negative correlation between the restoration provided by negative sound elements and the spatial enclosure. The greater the spatial enclosure, the lower the restoration provided by negative sounds. The coordination of small fountain sounds varied significantly across greenscapes, waterscapes, and hardscapes, illustrating that the consistency of sound with the visual landscape influences its soundscape restoration.

This study focused on the restorative effect of the soundscapes of office-type pocket parks to provide a basis for the optimal design of pocket park environments. Future research should continue to explore the restorative effect of soundscapes with different combinations of soundscape elements in different spatial environments to enhance the overall environmental quality and promote the recovery of urban residents' health.

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