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The Influence of Urban Green Space Soundscape on the Changes of Citizens' Emotion: A Case Study of Beijing Urban Parks

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Abstract: Coronavirus disease 2019 has significantly impacted mental health. Urban green spaces' ecological function can improve citizens' well-being and mental health; thus, this study explored the value realisation mechanism of ecological products in green space by examining the impact of urban green space soundscape on citizens' emotions. Additionally, we investigated citizens' subjective perceptions and emotional changes in soundscape through questionnaires. An A-weighted sound pressure level meter was used to measure the sound pressure levels at three points in a day to obtain the sound pressure level changes during different day periods in a park. Subsequently, the universal conclusion through a comparative analysis of the sound pressure level change in urban parks during the day was roughly 'M' shape. Further, a structural equation model analysed the influence of different soundscape on public sentiment and used a multigroup analysis to examine the difference in the impact of natural sounds in summer and winter on the change in public opinion. The results show that natural and living sounds positively affect citizens' emotions, whereas mechanical sounds negatively affect citizens' emotions. Furthermore, natural sounds in summer positively affect citizens' moods significantly. Conversely, natural sounds in winter negatively affect citizens' attitudes, but this is not obvious. Finally, this study proposed some suggestions for managing and improving urban green space soundscape.

Keywords: green space; soundscape; citizen sentiment; structural equation model; multigroup analysis

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1. Introduction

Regarding the coronavirus disease 2019 pandemic, the public's mental health has been affected substantially, persistently, and complexly [1]. The outbreak has led to numerous emotional reactions that have reduced the public's subjective well-being [2]. As the ecological services of the environment contribute to enhancing public well-being, there is growing interest in obtaining physical and mental health benefits from the environment. As many people support the positive effects of nature experiences on mental health, it is increasingly important to find ways to incorporate public health considerations into green space management [3]. A soundscape is a type of landscape in a green space that emphasises the reconstruction of the sound environment via human perception [4], one of the main contributing factors to the green space experience. Various disciplines focussing on soundscape research, such as psychology and sociology, have found that the acoustic characteristics of the environment can affect the health of individuals and their perception of green spaces [5]. Studies have shown that green space has a therapeutic effect on the human spirit, relieving tension and anxiety to a certain extent and improving attention and stress recovery [6–8]. Soundscape is vital in green space management and plays a significant role in improving public health. The effective management of green space soundscape can produce positive outcomes for public health and the well-being of citizens [9,10]. Urban residents are more seriously affected by negative emotions than residents in other places. Investigating the influencing mechanisms of soundscape in urban parks on citizens' emotional changes and exploring the impact of the sound environment on citizens' well-being is conducive to creating a comfortable and healthy living environment. This provides a new perspective on public health research.

1.1. The Impact of Soundscape on People's Emotions in Urban Parks

Urban parks are important and special urban green spaces, providing residents with a variety of important ecosystem services, such as reducing noise and improving urban environmental quality [11–13]. They are important green ecological and leisure spaces for residents [14–16]. Research on the negative impact of noise on health in urban environments has demonstrated the importance of sound in sustainable urban development [17]. Residents' perception of the soundscape of green space can reveal the interaction between people and urban parks, thus affecting the effectiveness of their management [18]. Therefore, it is becoming increasingly important to plan and manage urban green spaces from an auditory perspective [19]. 'Soundscape' is derived from the word 'landscape', which means 'landscape of sound' or 'auditory landscape' [20]. According to international standards established by ISO, a soundscape relates to peoples' perceptions or experiences and/or understanding of an acoustic environment. The soundscape is not a physical quantity but focuses on people's perception of the sound environment in a specific scene, or a social and cultural event [21,22]. The results of research on soundscape in many fields show that soundscape can affect individuals at physical, physiological, and psychological levels [23–25]. Human emotional changes are also inseparable from soundscape [26], which are affected by different types of soundscape elements and many other factors, rendering it a very complex system. Simply lowering the sound pressure level does not continually improve its comfort [27,28], or merely increasing natural sounds and reducing mechanical sounds does not create a harmonious environment in a certain sense. For citizens with different subjective characteristics, soundscape affect their emotions differently. Therefore, a sound source characteristics' differential control and scientific management are essential [29].

1.2. Methods of Measuring Emotions in the Environment

People interact with the environment, and various environmental elements directly affect their emotions [30]. Emotion is a psychological phenomenon that accompanies a person's life [31]; an almost unavoidable aspect of the inner psychological experience and the experience of human phenomena. Further, its primary function is to provide feedback so as to permit an effective response to the environment [32]. Incorporating emotion into related research on soundscape and exploring the emotional perception of soundscape is an integral part of soundscape research and supplements related research in psychology. Starting from the concept of the soundscape, the essential difference between pleasant sound and noise is emotional, and there is a transactional relationship between the soundscape and a person's emotional state. For example, being in harmony with one's emotions is considered positive [33]. However, the complex components of mental health, including happiness, sadness, anger, despair, and other psychological emotions [34], are superimposed on mental health [35]. Research on emotion at home and abroad is based chiefly on psychology. It mainly focuses on the qualitative analysis of subjective evaluation, divided into basic emotion and emotional dimensions. Standard research methods include self-report methods, for example, using various emotional evaluation scales, such as PANAS, POMS, SDS, PAD, and STAI, among others and other related content questionnaires to measure the subjective emotional experience of the subjects [35–39]. We used emotional semantic descriptions related to a person's feelings when hearing a soundscape to measure changes in emotion. Drawing on the PANAS, we divided emotions into two parts: positive and negative. Citizens in the park were assessed for mood changes.

1.3. Our Study Method

As the main consideration factors of green space landscape, research from the perspective of the visual landscape is far more than that from the standpoint of sound landscape. However, place experience should be an overall perception process. The perception of the five senses affects the formation of the audience's general perception, which directly determines the level of the audience's experience. Visual and auditory perception occupy the main cognition of people in the urban environment, and act together on individual perception in urban green space [40,41]. Although visual landscape perception is essential, soundscape represented by auditory perception cannot be ignored. Therefore, this research focuses on soundscape to study the well-being of urban green spaces for citizens. As the concern for humanism gradually turned to scientific research, previous research on soundscape also shifted from the study of objective physical attributes to the psychological perception of the audience. Thus, we further subdivided the small entry point of emotion at the intersection of environmental psychology, urban forestry, management, and other fields. This helped explore the impact of soundscape in urban green spaces on citizens' emotions and provided supplements for related aspects regarding the soundscape management of green spaces. We divided the measurement of sound into two parts: subjective and objective. The subjective part was to set up a questionnaire to divide the perception of soundscape into two aspects: loudness and frequency, to measure the perception of the public on the soundscape in the park, and the objective part was to conduct soundscape experiments, which selected three locations in each park with natural sound, living sound, and mechanical sound as the representative soundscape, and the A-weighted sound pressure level meter was used to measure the sound pressure level change in a day. Seasonal differences are an essential part of soundscape research; notably, there is a gap in current soundscape research. However, a few studies have conducted seasonal comparisons. People perceive different sounds in different seasons, and their emotional changes are also various. Therefore, this study innovatively conducted a multigroup analysis of seasonal differences to compare the impact of summer and winter soundscape on citizens' emotions. In the future, seasonal differences could be a concern for soundscape research.

This study measured the sound pressure level data of the soundscape of different urban parks in Beijing. Further, we evaluated citizens' subjective perception of the parks' soundscape and their emotional changes affected by the soundscape based on questionnaires. Structural equation modeling (SEM) was used to quantify the impact of different types of sounds on the different citizens' emotions. As it was found in the study that different seasons have specific interventions on the effect of soundscape on citizens' emotions, we also conducted a multigroup analysis comparing summer and winter. Thus far, this research has been divided into three parts: the characteristics of soundscape, the impact of different soundscape on citizens' emotions, and a multigroup analysis. This study explores the impact of urban park soundscape on citizens' emotions and proposes optimisation suggestions for park soundscape management.

2. Statistical Analysis and Research Hypothesis

This study involved multiple variables (potential variables) that cannot be directly observed. Thus, measurement errors may occur owing to the complexity of the dependent and independent variables. The traditional statistical analysis method does not allow for the measurement error of independent variables, so it cannot meet the needs of this study. Therefore, we chose the structural equation model. The structural equation model can explore and analyse complex multivariate research mathematics. SEM uses a covariance matrix of variables to analyse the relationship between variables, which can estimate the potential variables and parameters of the complex independent variable or dependent variable prediction model at the same time. Moreover, SEM allows independent and dependent variables to contain measurement errors [42,43]. The influence of urban park soundscape on citizens' emotions is a complex system with many variables and relationships. Hence, it is helpful to study the impact of urban park soundscape on citizens' emotions using a structural equation model.

In soundscape research, the sound environment is not simply regarded as a measurable physical quantity but as a series of sound elements that contain different information. The soundscape is a phenomenon with perceptual content [44]. Specifically, soundscape depend on people's perception of the sound environment in a particular place, and their research is also aimed at understanding the perception of the sound environment [45]. From the perspective of human settlements, studies on soundscape must ultimately return to the relationship between the soundscape itself and the perceiver (human). Many studies at home and abroad have demonstrated that soundscape play a vital role in psychophysical exploration, a common feature of sensory landscapes [9,46–48]. Scholars have conducted field research and experiments in urban open spaces and other places to explore the perception of soundscape, audience preferences for soundscape, and comfort evaluations [49,50]. An increasing number of studies have found that people are more relaxed when they mainly perceive natural sounds, and their negative emotions are reduced [17,51]. Compared with mechanical sounds (such as traffic and machine sounds), people usually prefer sounds made by people (such as conversational and the sounds of children frolicking). However, some studies have proved that the sounds of people will reduce the quiet feeling of the park [10]. Some scholars have evaluated the recoverability and rehabilitation of perceived soundscape. They found that a unique soundscape has positive and therapeutic potential for human health and happiness. Further, they evaluated a soundscape's potential psychological and perceptual rehabilitation function [5,52,53]. The subjective evaluation of soundscape is influenced by residents' age and educational background and interacts with residents' behaviours and activities [50,54]. Additionally, people's evaluation of sound comfort is greatly influenced by the type of sound source and the environment [47]; therefore, how can we explore the influence of soundscape on citizens' emotions? Considering that green spaces have incredible soundscape, which provide a suitable environment for studying the interaction between soundscape and people [46], we chose a city park as our study area. This study divides the soundscape into natural, living, and mechanical sounds using existing soundscape classification methods.

Based on citizens' subjective perception of soundscape and emotional changes after experiencing soundscape, we studied the influence of soundscape on citizen emotions. Related studies have shown that the loudness is higher for noise with high loudness, and the pleasantness is lower [44]. For example, with high-decibel and characteristic music, construction sounds, and other mechanical sounds, the citizens in the park have a strong perception of this volume, which has a low degree of comfort. Loud noises and the sounds of frolicking in public places also affect citizens' experiences in the park [55]. De Coensel and Dick Botteldooren found that quiet rural soundscape have a therapeutic effect on the overall mental health of the population and can help reduce mental fatigue [56]. Under the taxonomy of soundscape ecology, research and demonstration of soundscape restoration also found that the frequency of natural sounds with obvious positive recovery benefits was higher in the composition of the soundscape environment. In comparison, the frequency of artificial sounds with an apparent negative impact on recovery benefits was lower [52]. Additionally, some scholars have found through experiments that a single voice has different effects on the mental healing ability after adding other voices. People's psychological feelings of pleasure are related to dominant voices and other non-voice factors [57–59]. In summary, this study proposes the following hypotheses:

H1a: *Natural sound has a significantly positive impact on positive emotion.*

H1b: *Natural sound has a significantly negative impact on negative emotion.*

H2a: *Living sound has a significantly positive impact on positive emotion.*

H2b: *Living sound has a significantly negative impact on negative emotion.*

H3a: *Mechanical sound has a significantly negative impact on positive emotion.*

H3b: *Mechanical sound has a significantly positive impact on negative emotion.*

Under the current global pandemic circumstances, many countries have chosen to block and restrict people's actions as their primary strategy to fight the coronavirus disease 2019 pandemic. These actions have greatly affected environmental noise, improved the city's acoustic environment, and provided excellent opportunities for research on aural landscapes and public health [60]. For a long time, scholars' mainstream research on public health has included social, emotional, physical, intellectual, and spiritual aspects of health [3]. Emotion is one of the most critical aspects, which is implied in a person's actual social situation [61]. The soundscape is a sense. Experiencing the soundscape helps connect sensory and emotional experiences and affects people's health interests. Therefore, we explored the influence of soundscape on emotion, which is helpful in further planning urban parks to improve the health and well-being of tourists and their experiences.

3. Materials and Methods

3.1. Study Area

Four urban parks in Beijing, China, were selected as the study area for this study. We chose three locations in each park, and these three locations had different soundscape as the dominant sound (observation point of natural sound, observation point of living sound, and observation point of mechanical sound). Beijing's urban green space situation and citizens' reactions represent the country's capital.

Beijing is divided into urban areas and suburbs, and parks in which are correspondingly divided into urban parks and country parks. The characteristics and functions of urban parks and country parks are quite different, which is due to their geographical location. When we choose different parks, we consider the location of parks in Beijing. In terms of population density, the population density in the urban area of Beijing is higher than that in the suburbs. The population density in Xicheng District, Dongcheng District and Chaoyang District ranks among the top three. In terms of forest coverage, compared with urban areas, suburban areas have a higher forest coverage. Therefore, country parks mainly focus on wildness, while urban parks focus on the daily leisure and entertainment of citizens. Our research focuses on the improvement of soundscape in urban parks, so our study site is urban parks.

As there are many parks in Beijing, we have chosen one or two of the most representative ones among different types of parks. According to the classification standard of urban green space [62] and the reclassification of the types of urban parks in Beijing by Tao Xiaoli [63] and others, based on the universality of green space and the flow of people, four parks in Beijing were selected, as shown in Table 1. At the same time, according to the urban population density, we chose Chaoyang District, Dongcheng District and Xicheng District. Because the population of Chaoyang District is the highest and the types of parks are rich, we chose two urban parks in Chaoyang District, and one park in Dongcheng District and Xicheng District, respectively.

Table 1. Urban parks in Beijing.

Park	District	Area/Hectare
Beijing Sun Park	Chaoyang	288.7
Olympic Forest Park	Chaoyang	680.0
Beihai Park	Xicheng	71.0
Ditan Park	Dongcheng	37.4

Our study sites can be seen in Figure 1 below, which are four urban parks. The four parks have different characteristics and a different emphasis on the soundscape. Beijing Sun Park is a comprehensive park covering a large area. It is suitable for the public to conduct various outdoor activities, and provides recreational support for cultural entertainment and for children's activities. Therefore, the soundscape in the park is rich in types, mainly living sounds. Olympic Forest Park is an ecological park. The ecological park is the largest type of park in Beijing. It retains an excellent natural state, has a low degree of human interference, and has a high natural sound frequency. Many residents visit it on weekends to interact with nature and relax their mood. Beihai Park and Ditan Park are cultural heritage parks and small in scale. They have strong educational popularisation, tourism, and leisure functions. They allow the public to conduct parent–child education activities and rest tours. The presence of various soundscape in the park was relatively average. These four parks are reasonably typical in their respective park types, with a large flow of people, complementary functions, and complete sound types with different foci. Therefore, the results of the survey may be more apparent. Regarding the two types of parks not involved, community parks are more suitable for the residents' daily recreation in nearby residential areas. Citizens are familiar with the soundscape in the parks and have become accustomed to them, so emotional changes are not noticeable. Amusement parks are characterised by amusement, and their functions are relatively simple. The number of parks in Beijing is small and not representative.

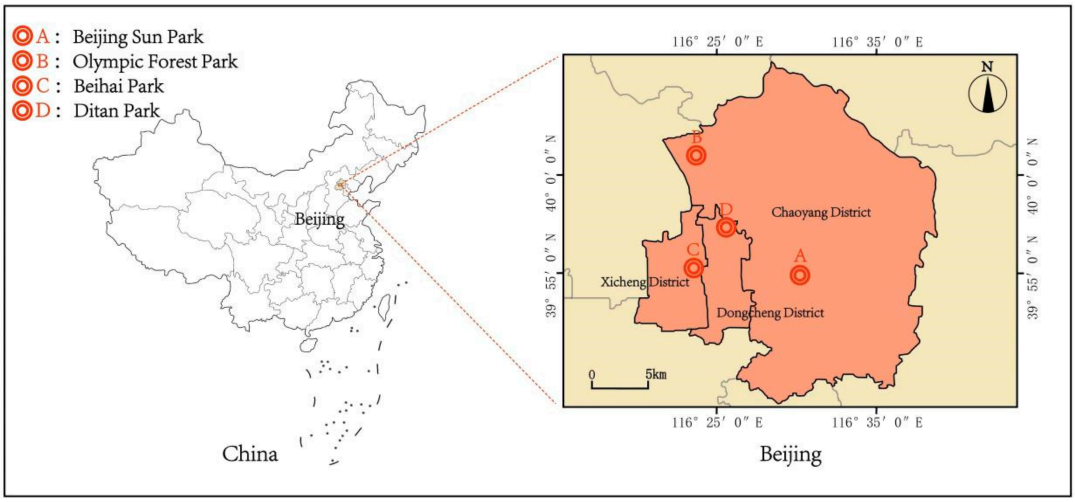


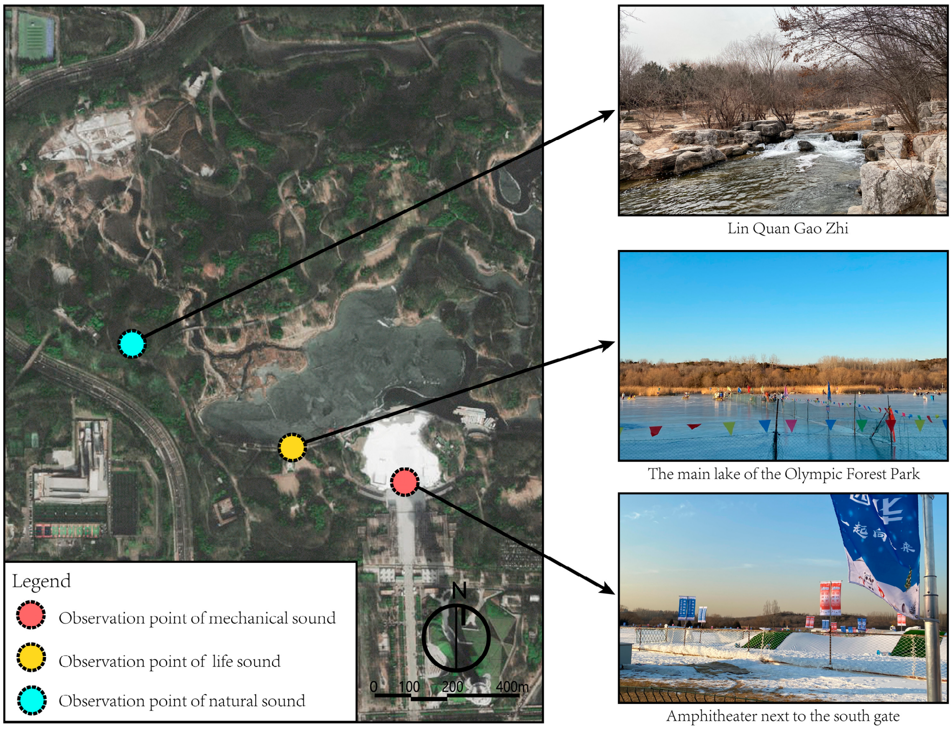
Figure 1. Locations of the study sites. Three districts with the highest population density were selected in the main urban area of Beijing, China, and 1–2 urban parks with high leisure function and eco-logical value were chosen in each district.

3.2. Soundscape Experiment Design

The sound pressure level is a physical quantity consistent with people's subjective perception of sound intensity in decibels (dB). The soundscape experiment in this study used a Smart Sensor AS804 sound pressure level meter with a range of 30 to 130 dBA and the frequency was A-weighted. The A-weighted sound pressure level reflects the subjective feeling of the objective noise intensity. The higher the sound pressure level, the greater the harm caused by the noise. As the noise value measured by the A-weighted network is closer to human ear perception and is easy to measure, many studies use the A-weighted sound pressure level to evaluate environmental noise and use it as an indicator for formulating and implementing relevant laws and regulations.

According to Lynch's theory [64], the city image results from a continuous verification in interacting with screened perceptual materials. The individual's experience in different environments directly affects their perception of space. Therefore, it is necessary to divide the study area into specific categories when designing soundscape experiments. Thus, this study categorises the main green spaces of urban parks into three types: (1) green space dominated by natural sounds, which refers to green space surrounded by trees or close to the lake, where the sound is mainly composed of bird calls, insect sounds, and water sounds. Green space dominated by natural sound is Beijing's main type of urban green space. It is also the most direct embodiment of the concept and method of green space development in the traditional sense. The main function of green spaces is to effectively establish an organic connection between humans and nature, thereby improving the health of citizens. Green space dominated by natural sound is the core concept of green space and an ideal form of green space construction. However, some scholars have pointed out that overemphasising the green coverage rate is not conducive to maintaining an excellent ecological environment. Therefore, in the construction of green spaces dominated by natural sounds, it is necessary to highlight the natural elements and consider the practicality of the green space. (2) Green space dominated by living sound refers to the green space around a volleyball court and tennis court, where the sound is mainly composed of the voices of citizens and the sounds of children frolicking. In terms of utilisation, green spaces dominated by living sounds have strong practicability, allowing people to return to nature during exercise or parent–child activities. The green space dominated by living sounds subtly conforms to the concept of 'harmonious coexistence between man and nature' and is an integral part of urban green space. (3) Green space dominated by mechanical sound. This refers to the green space in amusement parks, construction sites, and beside roads. The sound mainly consists of machine, traffic, and construction sounds. In addition, this kind of green space can be thought of as noise-polluted green areas. Further, this green space can effectively reduce mechanical sounds and play a buffering role. This study selected four parks' green spaces with natural, living, and mechanical sounds for sound pressure level observation. The observation points were determined according to the attributes of each location in the park and the surrounding environment. Taking Olympic Forest Park as an example, 'Lin Quan Gao Zhi' is located in the south-western part of 'Yang Mountain'. The valley formed naturally by the mountain is designed as a stream and waterfall. There are three pools and two peaks. It is a typical natural environment with few visiting tourists. Thus, the natural sound is the most usual; 'Olympian' is located on the north side of the open-air performance square, the central scenic spot in the Olympic Forest Park with many tourists. Further, many tourists visit for ice skating in winter because of the ice rink. There were many people in the venue, so the living sound was pronounced, and the open-air theatre near the south gate was close to the park's entrance. The traffic noise greatly affected this; it was equipped with a fountain water feature in summer. In winter, snow is made for the snowfield, so the sound of machine operation is also louder. Therefore, the mechanical sound is more apparent here. The specific sound-level observation points are shown in Figure 2.

Experiments were conducted on the weekends of August and November 2021. August is the high-temperature season in Beijing, and November is the beginning of the low-temperature season in Beijing. Therefore, the two can be compared and both periods are holidays. Therefore, during these periods, the characteristics of the soundscape of the inner green space are more apparent, and the experimental results are more typical. Given that Beijing's urban parks have opening and closing hours, this study divides the measurement time into 12 periods, with one hour as a measurement period, and the observation starts at 6 a.m. Three observation points were taken in each park, and their respective main soundscape types were natural, living, and mechanical sounds. The sound pressure level meter at the same location was repeatedly measured to reduce the influence of the environment during the measurement. Each observation point was sampled for 10 s, and finally, the sound pressure level data of each point were averaged as the final sound pressure level measurement result. In this study, the survey was conducted in summer and winter. Therefore, field measurements should be carried out in good weather conditions without rain, snow, or lightning, and the influence of wind speed on the measured values should be fully considered (wind forces above level 3 must be hooded to avoid wind noise interference, and winds above level 5 should be stopped) [65,66].



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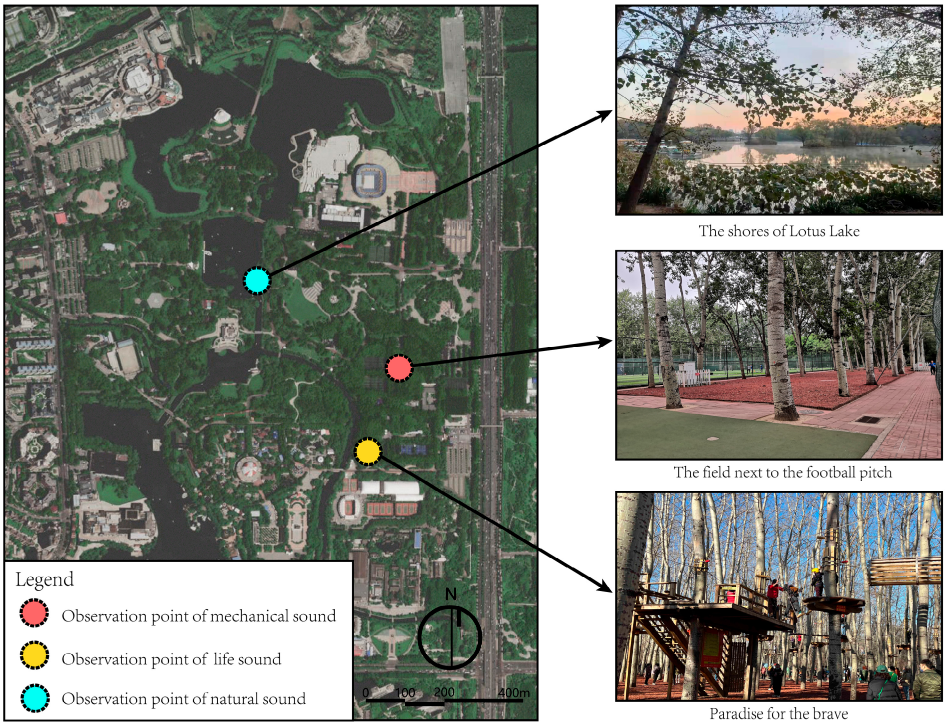
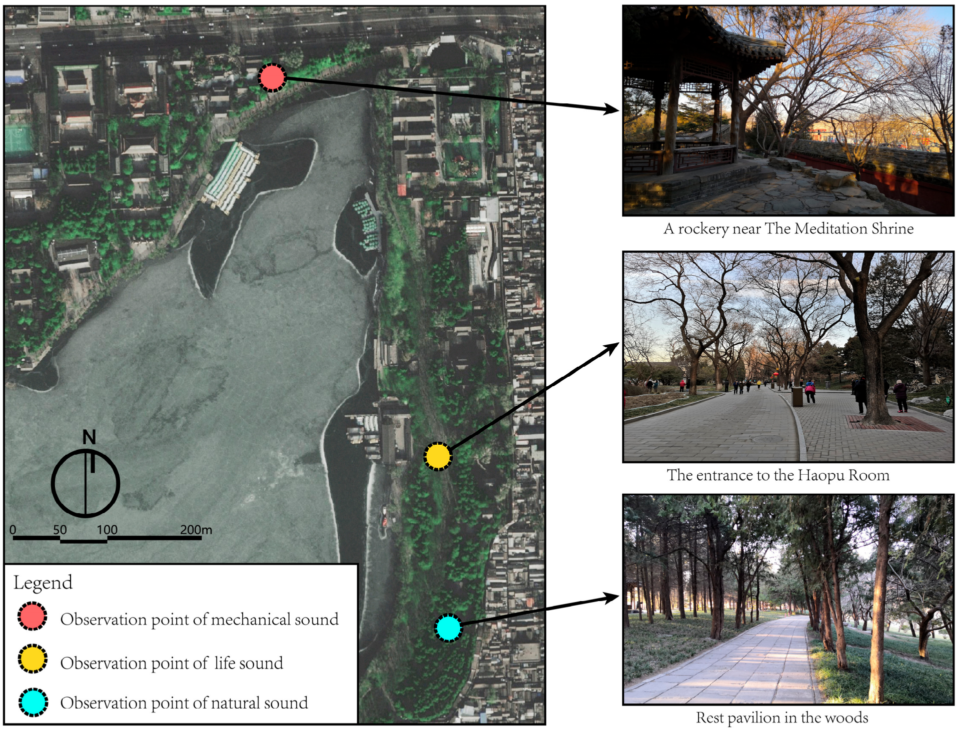


(**b**)

Figure 2. *Cont.*



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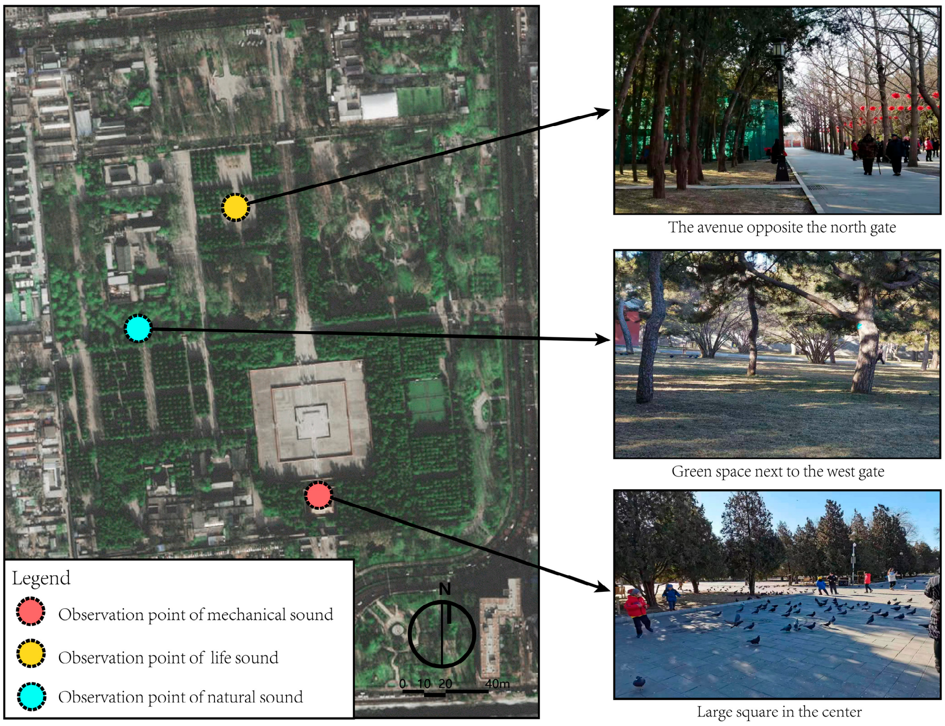

(**d**)

Figure 2. The specific sound pressure level observation points. (**a**) Olympic Forest Park; (**b**) Beijing Sun Park; (**c**) Beihai Park; (**d**) Ditan Park.

3.3. Questionnaire Design

This study refers to the existing research design questionnaire. It combines the results of the pre-investigation to modify and supplement the questionnaire to ensure the reliability and validity of the questionnaire, which experts have recognised. The questionnaire consists of three parts. The first part is the citizens' personal information, including gender, age, and education. The second part was the subjective perception measurement scale of the frequency and loudness of the soundscape. The third part was the measurement scale of the citizens' emotional changes. The latent variables are the perception of the three types of soundscape in the soundscape and the degree of change of the two kinds of emotions in the emotions. For the perception of the three types of sound landscapes, the questionnaire was designed in the following way. Based on the classification of soundscape by scholars in the past, we divided the soundscape into three categories according to their sound sources: natural, living, and mechanical sounds [26,67,68]. Therefore, we chose the perception of natural sounds, living sounds, and mechanical sounds as the latent variables. Specific sounds, such as the perception of bird calls and children's playful sounds, were used as the observed variables. Perception in the questionnaire was jointly reflected by the two dimensions of sound loudness [41,51] and frequency [48]. Among them, loudness perception represents citizens' subjective evaluation of the intensity of a specific sound, and frequency perception represents citizens' subjective judgment of the number of occurrences of a particular sound per unit of time. For the two kinds of emotions in the emotions, the questionnaire was designed in the following way. We used the PANAS scale [43] to measure emotional changes, which can effectively measure positive and negative emotions [69]. The PANAS scale has good reliability and validity and is suitable for the Chinese population [70]. Emotions were divided into two categories: positive and negative. The two latent variables, the degree of change in positive emotion and the degree of change in negative emotion are also observed by specific emotions, such as excitement and tension. The second and third parts of the test scale were measured using a 5-point Likert scale, as a 7-point Likert scale may create ambiguity for respondents [71]. The final formal questionnaire consisted of 5 latent and 19 observed variables (Table 2).

Table 2. Measurement items of latent variables.

Latent Variables	Items	Observed Variables	5-Point Likert Scale	
Natural sound	NS1 NS2 NS3	bird calls wind wind blowing leaves	Loudness: very low = 1 low = 2 generally = 3 high = 4 very high = 5	Frequency: very little = 1 little = 2 generally = 3 much = 4 very much = 5
Living sound	LS1 LS2 LS3	activities laughter children's frolic		
Mechanical sound	MS1 MS2 MS3 MS4	music traffic construction broadcast		
Positive emotion	PE1 PE2 PE3 PE4 PE5	excited inspiring active spirited enthusiastic	significantly weakened = 1 weakened = 2 no change = 3 enhanced = 4 significantly enhanced = 5	
Negative emotion	NE1 NE2 NE3 NE4	sad guilty annoying scared		

This study aimed to conduct interviews and collect relevant data comprehensively and objectively. We conducted a preliminary investigation in June 2021, determined the area and route of the data collection, and completed a small-scale pre-investigation of the questionnaire to ensure that the public fully understood it. The research team then optimised the researcher and questionnaire. The formal survey was divided into two seasons, summer and winter, and was conducted in August and November 2021 in four urban parks in Beijing. Questionnaires were distributed through convenience sampling. Our research location is the whole area of each park. During the investigation, the park is divided into several areas according to the number of researchers, and every two researchers are responsible for the investigation of one area. Our researchers were arranged to intercept visitors in the park and distribute questionnaires. The researchers waited for the interviewees to fill in the questionnaires, answering questions about the interviewees' doubts. We collected the questionnaires in writing. A total of 1000 questionnaires were distributed in this study, and 957 questionnaires were collected, with a response rate of 95.7%. In addition, we had obtained 901 valid questionnaires after excluding invalid questionnaires, including 350 in summer and 551 in winter, with an effective rate of 94.15%.

From the descriptive statistics of the valid questionnaires, we can see the general composition of the respondents: men and women were evenly distributed, and most of the respondents were aged 18–29 (53.13%). Nearly half of the respondents had a university degree (48.32%), and most were unmarried (64.88%). Additionally, more than half of the respondents had a monthly income of ¥4000 and below (50.56%).

4. Results

4.1. Diurnal Variation of Soundscape

4.1.1. Results of Soundscape Experiments

The results of the experiment of sound pressure level measure and practical investigations show that different sound types are the main reasons for the differences in the time distribution of urban park soundscape and are also affected by the park's attributes, the use of citizens, and so on. In this experiment, the sound pressure level was measured at the selected observation points, and the results are shown in Figures 3 and 4.

Combined with the trend diagrams of the sound pressure levels in different periods of various types of soundscape green spaces in parks in summer and winter, it can be seen that the sound pressure level of green spaces dominated by natural sound changes less throughout the day. Contrastingly, the sound pressure level of green spaces is overwhelmed by life and mechanical sound. These changes were relatively significant. The trend of change in the two seasons is roughly the same. Nonetheless, the range of change of the sound pressure level in the park in summer is smaller than that in winter, which may be because the wind speed changes significantly in different periods of winter in Beijing, resulting in a more significant impact on the measurement. Compared with the same park, the sound pressure level of the green space dominated by natural sound in summer can reach the same level as that in winter. This is because although there is a blessing of wind in winter, the creatures in the green space in summer are more active, such as cicada chirping, which may continue to produce an influence.

4.1.2. Citizens' Perception of the Soundscape

Based on the trend of change in sound pressure levels of green spaces dominated by different soundscape in urban parks, this study used loudness and frequency perception to discuss citizens' perceptions of different types of soundscape. This study uses a 5-point Likert scale to calculate loudness perception (1–5 points for 'very low–very high', 3 represents neither too high or too low), frequency perception (1–5 points for 'very little–very much', 3 represents neither too much or too little), and the results are shown in Table 3.

Figure 3. Trend diagram of sound pressure level in different time periods of various types of soundscape green spaces in four parks in summer. (**a**) Olympic Forest Park; (**b**) Beijing Sun Park; (**c**) Beihai Park; (**d**) Ditan Park. Notice: SPL represents Sound Pressure Level.

Figure 4. Trend diagram of sound pressure level in different time periods of various types of soundscape green spaces in four parks in winter. (**a**) Olympic Forest Park; (**b**) Beijing Sun Park; (**c**) Beihai Park; (**d**) Ditan Park. Notice: SPL represents Sound Pressure Level.

Table 3. The results of citizens' perception of soundscape.

Sound Types	Loudness Perception				Frequency Perception			
	Olympic Forest Park	Beijing Sun Park	Beihai Park	Ditan Park	Olympic Forest Park	Beijing Sun Park	Beihai Park	Ditan Park
bird calls	2.40	2.81	2.92	2.91	2.45	2.90	2.96	3.09
insects	1.82	2.75	1.62	2.12	1.89	2.14	1.70	2.20
wind	2.84	2.67	2.83	2.92	2.85	2.69	2.95	2.93
wind blowing leaves	2.40	2.71	2.15	2.78	2.46	2.85	2.23	2.90
water	1.93	2.59	1.91	2.14	1.97	2.75	1.91	2.27
bird calls	2.40	2.81	2.92	2.91	2.45	2.90	2.96	3.09
talking	3.16	3.17	3.52	3.13	3.24	3.30	3.57	3.23
children's frolic	3.21	3.32	3.17	3.31	3.07	3.31	3.21	3.23
footstep	2.89	3.11	2.54	2.58	2.81	3.05	2.73	3.07
laughter	3.22	3.25	3.26	3.34	3.20	3.30	3.11	3.34
activities	3.22	3.31	2.84	2.65	3.17	3.36	2.85	2.61
music	1.97	2.64	2.54	3.07	1.95	2.78	2.61	2.93
traffic	2.70	3.03	2.67	2.53	2.68	3.03	2.65	2.56
construction	1.86	2.64	1.45	2.12	1.64	2.71	1.42	2.02
fountain	1.63	2.94	1.49	1.88	1.46	2.72	1.49	1.82
broadcast	2.12	2.65	2.60	2.49	1.85	2.94	2.50	2.42

From the results of citizens' soundscape perception, it can be seen that among the three types of sound, the living sound is more evident to citizens. Among them, the sounds of conversation, children's frolic, and laughter are types of living sounds that citizens perceive to be louder and more frequent. This is consistent with the results obtained from the trend chart of sound pressure level changes in one day: an increase in the number of people in the park causes an increase in the sound pressure level.

Among natural sounds, citizens' perceptions of bird calls were higher than those of other natural sounds. This is because most urban parks in Beijing have a high degree of greenery that provides bird habitats. Conversely, pigeons, sparrows, and other birds were in the parks. They are not afraid of humans and interact with tourists more. In particular, the frequency of green bird calls mainly based on natural sounds is much higher than other natural sounds. This is followed by wind and the wind blowing leaves—there is an attaching relationship between the two sounds. The frequency perception of the wind sound was higher than that of the wind blowing leaves, but the loudness level of the two was nearly the same; in terms of frequency, the results of different parks were different. This is affected by the different types of water in the park and the distance between the citizens and the water. Taking Beihai Park as an example, citizens primarily rest along the shore of the North Sea, whose area is rather large with little liquidity. Therefore, at this time, the public's perception of the frequency of the sound of the water will be lower. For mechanical sounds, citizens' perception of loudness is generally higher, but it still does not exceed that of living sound. In addition, based on the interview results, it was found that citizens' perception of the frequency of traffic sounds varied over time. During the morning and evening peaks, the frequency perception of traffic sound was significantly higher than during other periods.

4.2. Influence of Different Types of soundscape on Citizens' Emotions

In this study, the structural equation model was selected using SPSS Windows software version 26.0 and Amos 24.0 to analyse the internal relationship among the latent variables. The hypothesis model uses the two-stage strategy proposed by Anderson and Gerbing (1988) [72]. In the first stage, the measurement model was verified by confirmatory factor analysis (CFA), mainly checking the goodness of fit, convergence, and discriminant validity of each potential variable and determining the relationship between each observed variable and the potential variable. In the second stage, the fit and path coefficients of the model hypothesis were measured by constructing a structural equation model with five potential variables: natural sound, living sound, mechanical sound, positive emotion, and negative emotion.

4.2.1. Reliability Test and Convergent Validity

In this study, Cronbach's α (alpha) and combined reliability (CR) were used to verify the constitutive validity and convergence validity of the model (Table 4). Cronbach's α values ranged from 0.726 to 0.960, exceeding 0.7 [73]. The CR ranged between 0.746 and 0.963. Therefore, the five facets have a good combination of reliability and convergent validity, and the measurement items of the questionnaire and model constructed in this study are reliable and reasonable.

Table 4. Internal and convergent reliability.

		UNSTD	S.E.	t-Value	*p*	STD	SMC	CR	AVE	Cronbach's α
Natural sound	NS1	1.000				0.888	0.789	0.746	0.511	0.726
	NS2	0.800	0.062	12.882	***	0.733	0.537			
	NS3	0.457	0.042	10.894	***	0.456	0.208			
Living sound	LS1	1.000				0.772	0.596	0.853	0.660	0.851
	LS2	0.977	0.042	23.370	***	0.815	0.664			
	LS3	1.188	0.050	23.637	***	0.848	0.719			
Mechanical sound	MS1	1.000				0.726	0.527	0.761	0.446	0.758
	MS2	1.050	0.067	15.640	***	0.731	0.534			
	MS3	0.848	0.059	14.290	***	0.600	0.360			
	MS4	0.832	0.055	15.149	***	0.602	0.362			
Positive emotion	PE1	1.000				0.898	0.806	0.838	0.524	0.794
	PE2	0.899	0.029	30.526	***	0.838	0.702			
	PE3	0.587	0.037	15.912	***	0.516	0.266			
	PE4	0.827	0.029	28.404	***	0.782	0.612			
	PE5	0.852	0.058	14.765	***	0.482	0.232			
Negative emotion	NE1	1.000				0.967	0.935	0.963	0.867	0.960
	NE2	0.968	0.013	73.706	***	0.961	0.924			
	NE3	0.983	0.014	69.575	***	0.951	0.904			
	NE4	0.937	0.022	42.120	***	0.839	0.704			

Note: *** $p < 0.001$.

This study used confirmatory factor analysis (CFA) to test the measurement model and to test the convergence validity of the model. The contribution of each measurement variable was investigated, along with the standardised factor loadings, t-value, significance level of each measurement index, and the average extraction variance of each potential variable. In this study, most measurement variables' standardised factor loadings exceeded 0.6, and three measurement variables with standardised factor loadings exceeding 0.45 could also be accepted [74]. The t-values ranged from 10.894 to 73.706, and the average extraction variance (AVE) ranged from 0.446 to 0.867, all of which were significant ($p < 0.001$) (Table 3). Except for the AVE value of mechanical sound being 0.446, the AVE values of all other potential variables exceeded the minimum required value of 0.5 [75]. Although the value of AVE is better than 0.5, it is acceptable that the AVE value exceeds 0.4 when the CR value exceeds 0.6. This is because, in this case, its convergence effectiveness is still sufficient [76,77]. Thus, the AVE value of mechanical sound was acceptable in this study, which does not majorly impact reliability and discriminant validity. Therefore, the results of the data analysis showed that each potential variable had good convergence effectiveness.

4.2.2. Discriminant Validity

Discriminant validity is the degree to which each latent variable is distinguished and is usually verified by the correlation matrix between variables. Therefore, the square root of the AVE for a variable needs to be greater than its correlation coefficient with other variables. According to the judgment matrix in Table 5, the square root of the average extraction variance of each potential variable is greater than the correlation coefficient between the potential variable and other potential variables, which proves that the measured data of this research model has good discriminant validity.

Table 5. Discriminant validity measurements.

	Mechanical Sound	Living Sound	Natural Sound	Negative Emotion	Positive Emotion
Mechanical sound	**0.668**				
Living sound	0.349	**0.812**			
Natural sound	0.326	0.129	**0.715**		
Negative emotion	0.287	0.127	0.144	**0.931**	
Positive emotion	−0.052	0.071	0.130	−0.004	**0.724**

Note: Bold numbers are the square roots of AVEs.

4.2.3. Structural Modeling and Hypothesis Testing

The maximum likelihood method was used to fit the structural equation model, and the initial model was modified according to the correction index to ensure the feasibility of the model. The final fitting result shows the standardised parameters of all path coefficients (Figure 5). Evaluation indices of the model goodness of fit showed a χ^2/df value of 3.384, while the root mean square error of approximation (RMSEA) was 0.051 (Table 6). The model's absolute, value-added, and simplified fitness indices all meet the evaluation criteria, indicating that the overall validity of the final model is good.

Table 6. Model fitness test (n = 901).

Fitness Index	Absolute Fitness Index			Value-Added Fitness Index				Simplified Fitness Index		
	RMSEA	SRMR	GFI	AGFI	NFI	CFI	IFI	PGFI	PNFI	PCFI
Evaluation standard	<0.07	<0.05	>0.9	>0.9	>0.9	>0.9	>0.9	>0.5	>0.5	>0.5
Fitting value	0.051	0.061	0.945	0.926	0.951	0.965	0.965	0.711	0.796	0.807
Judgment	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Four hypotheses were supported, while two did not pass the test (see Table 7 and Figure 5), Mechanical sound had a significant positive effect on negative emotions (standardised path coefficient = 0.258, $p < 0.01$), supporting H3b. Natural sounds have a significantly positive intention to change positive emotions, supporting H1a. Mechanical sounds negatively impact positive emotions, supporting H3a. The living sound positively impacted positive emotion, supporting H2a. H1b and H2b were rejected because there was no significant relationship between natural sound and negative emotion, living sound and negative emotion.

Table 7. Hypotheses testing using the modified model.

Hypothesis	Path	Standardized Factor Loading	Standard Error	t-Value	*p*	Result
H1a	NS → PE	0.163	0.031	3.871	***	Supported
H1b	NS → NE	0.057	0.036	1.461	0.144	Unsupported
H2a	LS → PE	0.098	0.036	2.37	**	Supported
H2b	LS → NE	0.03	0.042	0.762	0.446	Unsupported
H3a	MS → PE	−0.14	0.046	−2.971	**	Supported
H3b	MS → NE	0.258	0.057	5.539	***	Supported

Note: ** $p < 0.05$, *** $p < 0.01$.

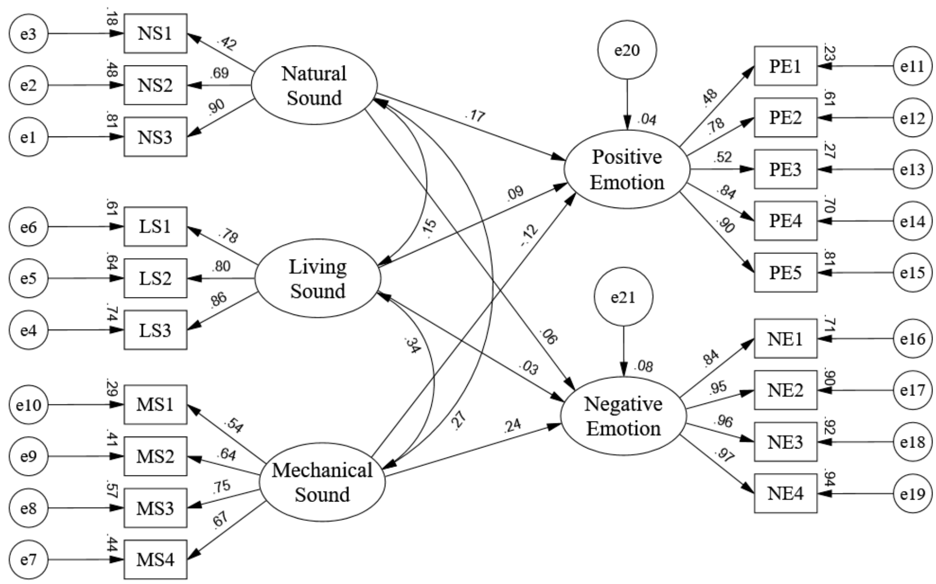

Figure 5. Path diagram of the structural equation model.

4.2.4. Multigroup Analysis with the Season as the Adjusting Variable

In the field investigation, we found a big difference between the natural sound in Beijing green space in summer and winter. Its influence on positive and negative emotions is also quite different. The natural sounds we studied were composed of wind, the wind blowing leaves, and birds. Overall, the wind in the summer was smaller than that in the winter. Moreover, the zonal vegetation in Beijing is a deciduous broad-leaved forest. In summer, the leaves are luxuriant, and the sound of the wind blowing leaves is loud. In winter, the sound of the wind blowing leaves is somewhat affected after some tree species fall. As for birds in the green space, the migratory birds in Beijing are divided into summer migratory birds and winter migratory birds because spring and autumn are bird migration periods, and the stable period of birds is summer and winter [78]. Some studies have shown that the number of birds in Beijing is largest in winter and smallest in summer [78–80]. Therefore, seasonal differences had a more significant impact on bird calls. Thus, the effect of natural sounds on emotion is worth exploring under the influence of seasonal differences. As the aforementioned structural equation model can only solve the path analysis problem of the whole sample, it cannot compare and analyse two independent samples across the entire sample. Nevertheless, multigroup analysis can solve this problem well. Therefore, we chose a multigroup analysis to examine the difference in the path influence of natural sounds on positive and negative emotions in the background of summer and winter.

This study tested the measurement weighting weight, structure weight, structure covariance, structure residuals, and residual measurement models. Table 8 shows that the CMIN/DF and RMSEA of the first five models are within the acceptable range, and the GFI, NFI, RFI, IFI, TLI, and CFI are also within the acceptable range, which meets the requirements of the moderate replication of the multigroup equality test. These results indicate that the model was stable.

We further processed the data to compare the differences between summer and winter. The results are presented in Table 9. It can be seen that most models' changes in GFI, NFI, RFI, IFI, TLI, and CFI exceed 0.05. Further, the p-value is less than 0.05, which shows that the influence of natural sounds on positive and negative emotions is notably different in the two seasons.

Table 8. Model adaptation table.

Model	CMIN/DF	RMSEA	GFI	NFI	RFI	IFI	TLI	CFI
Unconstrained	3.18	0.049	0.943	0.959	0.948	0.972	0.964	0.971
Measurement weights	3.287	0.05	0.936	0.954	0.946	0.967	0.962	0.967
Structural weights	3.583	0.054	0.932	0.949	0.941	0.963	0.957	0.963
Structural covariances	3.561	0.053	0.932	0.949	0.942	0.963	0.957	0.963
Structural residuals	3.522	0.053	0.931	0.948	0.942	0.963	0.958	0.962
Measurement residuals	7.912	0.088	0.878	0.872	0.87	0.887	0.885	0.887

Table 9. Invariant analysis.

Model	Delta-CMIN	Delta-DF	*p*	Delta-GFI	Delta-NFI	Delta-RFI	Delta-IFI	Delta-TLI	Delta-CFI
Measurement weights	40.714	9	0	−0.007	−0.005	−0.002	−0.005	−0.002	−0.004
Structural weights	81.365	11	0	−0.011	−0.01	−0.007	−0.009	−0.007	−0.008
Structural covariances	82.362	12	0	−0.011	−0.01	−0.006	−0.009	−0.007	−0.008
Structural residuals	84.884	14	0	−0.012	−0.011	−0.006	−0.009	−0.006	−0.009
Measurement residuals	697.903	26	0	−0.065	−0.087	−0.078	−0.085	−0.079	−0.084

Table 10 shows that natural sound has a significant positive effect on positive emotion (β = 0.378, $p < 0.05$), and also has a significant positive influence on negative emotion (β = 0.222, $p < 0.05$) in summer. However, the path coefficient of natural sound for positive emotions is greater than for negative emotions. In the context of winter, natural sound has no significant influence on both positive and negative emotions.

Table 10. Path coefficient difference analysis.

Path	Summer		Winter	
	Estimate	*p*	Estimate	*p*
Natural sound → Positive emotion	0.378	***	−0.063	0.155
Natural sound → Negative emotion	0.222	***	0.078	0.065

Note: *** $p < 0.01$.

5. Discussion

5.1. Urban Soundscape Features

Overall, the entire sound pressure level of the park exhibited varying degrees of shape over time. Combined with the results of field experiments and interviews in the four parks, the reasons for sound fluctuations are as follows: From 6:00 to 8:00 in the morning, there are few people in the park, and the living and natural sounds are the same. Taking Olympic Forest Park as the representative, some construction sites in the park began construction, and the sound of machinery was slightly higher. The period 8:00–10:00 in the morning is the morning rush hour in Beijing. Citizens begin to commute; therefore, traffic noise levels continue to increase, and mechanical sound enters the first stage of increase. Simultaneously, some citizens began to enter the park one after another. During the period of 10:00–12:00 in the morning., an increasing number of citizens came to the park for recreational and entertainment activities. The living sound, mainly the sounds of conversation and children frolicking, gradually increased and remained relatively stable. Music sounds, dominated by broadcast sounds, also appear in various parts of the park. At this time, the sound pressure levels of green spaces dominated by living and mechanical sounds can reach approximately 70 dBA. Contrastingly, the sound pressure level of green spaces dominated by natural sound was relatively low, between 12:00 and 14:00, during which time some citizens who came to the park in the morning left, but many had meals and lunch breaks, and the sound pressure level of each observation point generally decreased. From 14:00 to 16:00, the number of citizens in the park began to increase again, and various entertainment activities and conversations appeared one after another, reaching their second peak. The construction department also began to work, and the sound pressure level generally increased. During 16:00–18:00, some recreational facilities in the park were close to closing, some parks began to close, citizens gradually left the park, and the sound pressure level was reduced. The mechanical sound was higher than the other two sounds.

Generally, over time, the overall sound pressure levels of various types of green spaces show different degrees of 'M' shaped change trends. Further, the above changes in sound pressure levels are mostly related to the increase or decrease in the number of people in the park. However, owing to the differences in the attributes and functions of the four parks, the natural sound pressure level of Olympic Forest Park, which has the highest degree of greening, is greater than that of the other three parks, which can reach 55 dBA or more. As a family-based group, the survey found that most tourists in Beihai Park took their children to the park to accompany older adults, to watch scenic spots, to relax, and to spend their vacations. Birds and small animals in the park interacted with tourists more clearly. Therefore, the sound pressure levels of various sound changes are not apparent. Beijing Sun Park has more amusement facilities than other parks. Furthermore, most tourists take children for entertainment, so the living sound is greater than in other parks during the two peaks. Ditan Park, most of whose tourists are older, and most citizens go home to eat and rest during noon. Therefore, the living sounds were relatively small during this period. Pigeons and other birds raised in the park entered the feeding stage. Simultaneously, cicadas and other creatures are active in summer. Consequently, the natural sound is amplified and is larger than the living and mechanical sounds.

5.2. Analysis of the Impact of Soundscape on Emotion

Generally, natural sounds positively impacted positive emotions (H1a, β = 0.163). Natural sounds, such as bird calls, wind sounds, and the wind blowing leaves will enhance people's positive emotions and make them feel more energetic and enthusiastic. This study suggests that bird calls can be extended to animal sounds, such as insect sounds. This is similar to the results obtained by Brown [47] and Jing [5]. Compared with other sounds, natural sounds, such as animal sounds and wind sounds, can promote people's mental health and positive emotions and simultaneously increase outdoor activities' fun. Additionally, this study found that natural sounds positively impact negative emotions. However, it failed to pass the significance test, indicating that natural sounds had a negligible positive impact on negative emotions. Natural sounds also had little effect on the promotion of negative emotions. This paper argues that citizens will have different emotional responses to natural sounds of varying loudness and frequency. For example, gentle wind and the right bird calls bring people a pleasant feeling they relate with quiet spaces [81]. However, the whirring of strong winds or noisy and dense bird calls causes some people to have negative emotions, such as boredom. Compared with the data of sound pressure level, the sound pressure level of green space dominated by natural sound is lower than that of the other two types of green space, only 40–60 dBA. This indicates that cultivating urban green space with natural sound is still lacking.

Living sounds positively affected positive emotions (H2a, β = 0.098). Living sounds, such as activities, laughter, and children frolicking, can make people more energetic and inspired. The voice of life can be positively perceived in the natural environment [3]. The research by Hyun In Jo et al. also supports this view [17]. Furthermore, the sounds of life can make people feel relaxed. Our study found that living sounds can also promote the generation of negative emotions, but this is insignificant, indicating that the effect is negligible. This result is consistent with the research of Payne et al., who found that the human voice negatively affects sound environment improvement [82,83]. As the sound of life is more complicated, it sometimes positively impacts people's emotions, and sometimes it has a negative effect [84–88]. In this study, living sounds positively influenced people's emotions toward urban parks. Given that 97.28% of the people in this study went to the city park to relax and entertain, this supports the idea that people's voices inspired more positive emotions. Moreover, the sound pressure level of the green space dominated by living sound is higher during the day, reaching 50–70 dBA and sometimes reaching up to 80 dBA, indicating that the living sound of urban green space in Beijing is sufficient.

Mechanical sounds negatively influenced positive emotions and had a significant favourable influence on negative emotions (H3a and H3b). Mechanical sounds, especially construction and broadcasting sounds, increase citizens' negative emotions and adversely affect their mental health. Construction and broadcast sounds are the main components of mechanical sounds, which is the main factor in reducing the quality of sound landscapes in urban parks [89]. This result is similar to that of most previous studies. For example, Szeremeta et al. and Hyun In Jo et al. believed that the sounds of machines, traffic, radio, and telephones negatively affect people's health and happiness [17]. Yet, when measuring the sound pressure level of the three types of green spaces in each park in one day, we found that the mechanical sound was high, sometimes up to 90 dBA, producing more noise, which affected the hearing of the visitors.

Simultaneously, our research found that the soundscape of Beijing in winter and summer were significantly different. The most obvious ones are the wind and the sound of the wind blowing leaves. In summer, the wind is low, and the sound of leaves rustling is softer, bringing comfort to the public. However, in winter, the wind in Beijing is loud, and the frequency is also high, which often causes irritability and other emotions. In summer, natural sounds can significantly promote positive and negative emotions; however, they have a more significant effect on positive emotions ($\beta = 0.378$). In summer, the sounds of wind, of the wind blowing leaves, and of bird calls can arouse citizens' positive emotions, but high-frequency sounds can cause certain negative emotions. Natural sounds in winter had no significant effect on positive and negative emotions, indicating that they had little effect on emotion. However, we can also see that natural sounds negatively impact people's moods in winter.

In addition, when people perceive the natural environment, audio-visual interaction also plays a role [90,91]. For example, vegetation has played a certain weakening effect on people's perception of noise, not only due to the physical shielding weakening, but also the soothing emotions after people see green vegetation. In the study, we also found that citizens who filled out questionnaires in green vegetation or fountains were more neutral in their perception of loudness and frequency, and their emotions were more positive.

5.3. Rationality and Limitation

This study mainly adopted the experimental methods of sound pressure level measurements and questionnaire surveys that have been used in previous studies. This study expounds on the influence of different types of soundscape on emotions through these two research methods. Further, it analyses the sound pressure level difference of soundscape in different seasons and the impact of these differences on people's emotions. Regarding the method of sound pressure level measurement, there have been studies on the the measurement of sound pressure levels in spaces using a sound pressure level meter [10]. For our questionnaire content design, existing studies have also adopted this soundscape classification [26,67], and our emotion scale design has adopted a proven and effective mature psychological scale [70,92]. This indicates that the results of our research are reasonable.

However, this study had some limitations. We only selected Beijing as a typical city and its type of urban park. Although we chose urban parks with different leading functions, they still cannot represent all green spaces. Future research should expand the scope of urban choices and appropriately increase the number of types of green spaces. At the same time, the content of audio-visual interaction can be added.

6. Conclusions and Suggestions

6.1. Conclusions

In this study, we used sound pressure level meters to measure sound pressure level changes in four urban parks in Beijing over a day. Three observation points were selected for each urban park, and each point was dominated by one type of sound. From this, we can conclude that the trends of change in summer and winter in urban parks are the same, and both are in the 'M' shape. However, the sound pressure level in winter is higher than in summer, which may be because the sound pressure level of the wind sound in winter is higher than in summer. Simultaneously, we conducted questionnaire surveys in four urban parks during the two seasons. The survey results showed that natural and living sounds could promote positive emotions, whereas mechanical sounds can lead to negative emotions. Further, comparing summer and winter, we found that natural sounds in summer had a more significant impact on people's emotions. Natural sounds in summer may make people experience more positive emotions but can also result in negative ones, though these are weaker than positive ones. Conversely, natural sounds in winter have little impact on people's emotions but can still negatively affect them. We estimate that this may be related to the higher sound of the wind in Beijing during winter.

6.2. Suggestions

Urban green spaces have ecological services that positively impact citizens' emotional health and perception of happiness. Therefore, our main aim is to improve urban green spaces' ecological service function and realise the value of ecological products. Thus, from the perspective of urban green space sound landscape planning and management, based on people's emotional health needs, this study puts forward the following suggestions:

(1) Increase and enrich the flora and water systems, protect and cultivate natural sounds, and artificially disperse mechanical sounds. Due to the loss of global biodiversity, natural sound is facing increasing pressure. However, we need natural sound to play its positive role in green spaces [93]. First, existing natural sounds in the park should be protected while cultivating other natural sounds. We can increase and enrich the flora and water systems in green spaces to attract birds and insects to live. Since birds are dominant creatures that produce abundant sounds in urban forest ecosystems, this creates a green space with more hierarchical animal sounds [94]. Rich plants can also create a green space with more abundant wind-blown leaves. Simultaneously, plants can disperse strong winds in winter and reduce their interference with citizens' emotions. In places where mechanical sound is large, such as the junction of green spaces and highways and broadcasts, plants or water systems can be appropriately set to weaken mechanical sound and minimise the impact of mechanical sound on public sentiment. In green spaces, staff can attempt to use quieter vehicles and construction equipment. Simultaneously, the staff can reasonably arrange the loudspeakers' location, quantity, and efficacy in the green space. Regarding citizens' high-decibel loudspeakers, the management of the space can include strictly limiting the period for which they can be used.

(2) Space separation provides living sounds in a specific space. Since different citizens have different preferences for people's voices, the appropriate partition of space where living sounds occur, and the overall green space, will help citizens with various needs enjoy a comfortable sound environment. Residents with negative emotional reactions to the living sound can enjoy recreation in a space with less sound, while residents who prefer the sound of life can go to a 'living sound space'. Proper arrangement of sound-inducing facilities, such as exercise facilities in 'living sound space', can effectively stimulate the positive emotions of citizens.

(3) Introduce professionals who actively understand visitors' soundscape preferences and can reasonably improve the soundscape in green spaces. Urban green space management departments can appropriately introduce people to further knowledge about the sound environment. Furthermore, they can draw up detailed sound land-

scape management plans to make reasonable plans for the sound environment of green spaces. This would make the green space more responsive to the needs of the residents. In green spaces, guide signs or maps of the acoustic landscape can be set to guide citizens to their preferred acoustic landscape locations. Simultaneously, through investigation, and cooperation with school institutions, etc., green spaces can actively explore the public's measurement and preference evaluation of the soundscape. According to the public's assessment and evaluation, all types of soundscape within green spaces can be improved.

(4) Strengthening the popularisation and publicity of the soundscape theory: soundscape has not received sufficient attention in green space management, so it is necessary to enhance the popularisation and promotion of soundscape knowledge for administrative personnel, social organisations, and civil groups. Additionally, soundscape awareness within the planning departments, and amongst investors and citizens should be improved. This can be achieved by integrating publicity into the landscape in the green space, adding elective courses on soundscape in schools, and promoting social organisations.

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