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The Effect of Soundscape on Sense of Place for Residential Historical and Cultural Areas: A Case Study of Taiyuan, China

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Abstract: A soundscape carries the culture and memories of historical and cultural areas, capable of evoking people's emotions towards a place. This paper aims to explore the influence of the soundscape on the sense of place in historical and cultural areas using a mixed-method approach. Conducting on-site measurements, questionnaires, and semi-structured interviews in four areas in Taiyuan, China, this research utilized structural equation modeling and grounded theory for analysis. Research findings: Firstly, the soundwalk method identified 11 categories of soundscapes and the main sources of noise in residential areas were traffic sounds and commercial sounds. Secondly, residents showed the highest preference for natural sounds and traditional activity sounds. Preferences for activities' sounds and traditional sounds, along with the perceived frequency of daily life sounds, entertainment activities' sounds, and natural sounds were positively associated with the sense of place, while the perceived frequency of commercial sounds, traffic sounds, and pet sounds was negatively associated. Lastly, from the grounded theory, this research showed that traditional sounds effectively enhanced residents' sense of place by triggering memories, embodying culture, and connecting emotions. Daily life sounds linked residents' lives and prompted visions, while local dialects evoked emotion and culture. Activities' sounds served as lubricants for the place, primarily triggering residents' sense of place from a lifestyle and emotional connection.

Keywords: soundscape; place attachment; historical districts; grounded theory

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1. Introduction

Historical and cultural areas are the roots of urban memory and the source of culture, serving as the emotional anchor for residents. The relationship between the preservation of historical heritage and urban renewal is not incompatible [1]. Protecting historical and cultural areas and places of various architectural heritage, is a positive measure for achieving urban development and renewal. It is crucial for the sustainable development of historical heritage [2]. Residential historical and cultural areas, compared to those focused on tourism and commerce, primarily consist of local residents. Residents are a group with long-term subjective understanding and emotional attachment to historical and cultural areas, endowing this space with core values and significance. Their activities take place within these districts, where visual and auditory perceptions are unavoidable elements of their experience. The visual and auditory perception of historical and cultural districts can trigger residents' emotions and sense of identity [3,4], contributing to the sense of place [5]. Exploring and delving into the construction of a sense of place among residents in historical and cultural areas holds significant academic research value. The soundscape itself has been defined in the ISO 12913-1:2014 as follows: "acoustic environment as perceived or experienced and/or understood by a person or people, in context" [6]. The soundscape contains rich characteristic information, and exploring how it stimulates a

sense of place in residential historical and cultural areas and how constructing soundscapes can enhance residents' sense of place is essential for improving the livability and sustainable development of these areas.

Sense of place involves individuals' behaviors, values, and encompasses both social and natural aspects [7]. In the study of the relationship between people and their environment, historical and cultural areas were not static locations on a map; they were dynamic combinations of individuals and activities [8]. Sense of place, as described by Tuan (1977), represents the meanings and attachment to environment held by an individual or group [7]. It reflects the processes of identification, dependence, and alteration of a place, along with the identity, values, and emotions associated with that place [9]. It is an inclusive term with relatively fuzzy dimensions, including place attachment, place identity, and more [7,10,11].

Place attachment is the emotional connection between people and a place. Places are dynamic, and place attachment can be a powerful force for adaptation in the face of the changing social context of historical and cultural areas [12]. Residents' sense of place cannot be separated from the emotional connection between people and their environment, which is why this study introduces place attachment as a dimension of sense of place.

Place identity, initially introduced by Proshansky, was defined as the personal identity of individuals with the physical environment through complex patterns of conscious and unconscious concepts, emotions, values, goals, preferences, skills, and behavioral tendencies [13]. Scholars used place identity to distinguish one place from another and to gauge an individual's level of identification with a place [14]. In residential historical and cultural areas, where the resident population is relatively stable, exploring social status, roles, and participation can start with place identity. Therefore, this research focused on the social construction of a sense of place through the dimensions of place attachment and place identity, based on local culture and resident activities.

In the soundscape, people, sounds, and environment intertwine to form a sense of place, embodying the essence of cultural geography [15]. Exploring urban sustainable development requires attention to the design and environmental conservation of historical districts. During the architectural design phase of historical districts, the predictive potential of artificial neural network modeling is being emphasized [16]. In the research on the built environment configuration of historical districts, Amen et al. explored the relationship between street layout centrality and walkability, emphasizing the importance of considering street network configuration in designing urban layouts for sustainable tourism [17]. While extensive research is being conducted on the built environment of historical districts, some scholars are also interested in the applicability of soundscapes to sense of place [18]. Soundscapes, cultural heritage, and public spaces complemented each other [19]. There was a close relationship between historical and cultural backgrounds, soundscapes, and the natural environment. Soundscapes were consistent with the local natural environment and historical and cultural background [20]. They played a significant role in shaping historical atmospheres and promoting cultural landscape perception [21]. In European studies of historical and cultural heritage, scholars found that soundscapes played a crucial role in people's restorative perception and happiness [22]. Some historical sites had unique soundscapes, worthy of maintenance and management based on tourism and cultural values [23]. Establishing quiet areas in historical and cultural areas could enhance community belonging, identity, and emotional connection [24]. In China, researchers have found that different types of historical districts in Harbin show different soundscapes [25]. During the research on Fuzhou's historical and cultural areas, Liu et al. found that the pleasantness and eventfulness of soundscapes had a greater positive effect on historical landscapes and modern landscapes, respectively [26]. Additionally, the natural sounds of historical and cultural districts played a vital role in relieving residents' psychological stress [27]. In terms of research methodology, within quantitative research, structural equation models could explore the relationship between soundscape perception and visitor experiences [26]. However, there is a significant lack of empirical research on

the mediating effect of soundscape perception in historical and cultural areas on the "resident–place" relationship. It is appropriate to use structural equation modeling to explore the potential mediating role in this relationship [28]. The collection methods of qualitative data are diverse. Afolabi et al. downloaded a large number of documents from the database and adopted the literature research method to conduct a systematic review of the published literature to collect qualitative data [29]. Kang et al. utilized the grounded theory approach to analyze the preference process in perceived soundscapes and semantic coding [30]. People became increasingly interested in the relationship between soundscapes and subjective well-being [31]. Acoustic satisfaction was largely related to factors such as the physical environment, cultural identity, subjective evaluation of the built environment, and more [25]. The sounds individuals noticed depended not only on the composition of the auditory environment but also on past experiences, current activities, expectations, and other influences [32]. Therefore, a comprehensive coverage is needed in the analysis of the research.

Visual landscapes have been extensively studied in terms of individual emotional dimensions and the role of place attractiveness [33,34]. High-quality physical and social environments indeed contribute to enhancing a sense of place [35]. Similarly, soundscapes can promote place attachment in historical and cultural areas [36], and there are differences in the impact mechanisms of place attachment on tourists and residents' sense of place and satisfaction [37]. As mentioned above, sense of place, as a perceptual indicator of historical and cultural areas, has been less systematically studied in terms of how soundscapes shape residents' sense of place. Revealing the intrinsic correlation between soundscapes and sense of place from the perspective of sound perception and experience can deepen the understanding of the role of sound factors in local emotions in the theory of the human–environment relationship. From the perspective of the "human–sound–place" system, this paper explored the mechanism of how soundscapes triggered residents' sense of place in historical and cultural areas, as well as how to enhance residents' sense of place through the construction of soundscapes. It innovatively conducted empirical research on the effect of soundscape perception in historical and cultural areas on the "resident–place" relationship, and constructed a model of the influence mechanism of residents' sense of place in historical and cultural areas based on soundscape perception. This research enriched the cultural geography's understanding of place theory and the exploration of soundscape theory.

2. Materials and Methods

2.1. Site Selections

Taiyuan, China, formerly known as "Jin", was designated as a national-level historical and cultural city in 2011. The city encompasses five historical and cultural areas, among which Nanhuamen district, Dongsandao lane, Taiyuan Mining Machinery Factory Dormitory, and the Soviet Experts' Building of the Taiyuan Heavy Machinery Plant are residential districts, representing the cultural and industrial heritage of Taiyuan's city. The main residents of these residential districts are local inhabitants (Figure 1).

The Nanhuamen Historical and Cultural Area (hereafter referred to as "Nanhuamen District") covers an area of 26.88 hectares. It preserves cultural heritage sites such as Xu Fanting's former residence, the Old Site of Ximenghui Taiyuan Committee, and Zhao Shuli's old residence, showcasing the historical appearance of Shanxi Province's military and political functions during the Republic of China and the early 1950s period.

The Dongsandao Lane Historical and Cultural Area (Dongsandao Lane) covers an area of approximately 1.99 hectares. It features ancient-style quadrangle courtyards and brick-arched gates with distinctive era characteristics. The lane combines old and new buildings, exuding a vibrant atmosphere and reflecting the traditional appearance of residential homes from the Qing Dynasty to the Republic of China era.

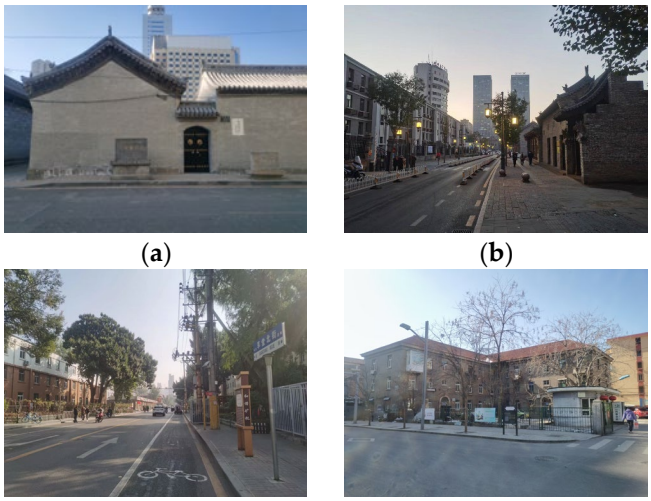


Figure 1. Sites selected for field investigations. (**a**) Nanhuamen District; (**b**) Dongsandao Lane; (**c**) Taiyuan Mining Machinery Factory Dormitory; and (**d**) Taiyuan Soviet Experts' Building.

The Taiyuan Mining Machinery Factory Dormitory Historical and Cultural Area (Taiyuan Mining Machinery Factory Dormitory) covers an area of 21.1 hectares and is one of Taiyuan's important industrial residential areas. It was constructed in the early days of the founding of the People's Republic of China to improve the living environment of workers. Designed using drawings provided by Soviet experts at that time, it retains typical layout and historical remnants such as the mining machinery factory expert dormitory, workers' dormitories, and the former site of the mining machinery club.

The Soviet Experts' Building of Taiyuan Heavy Machinery Plant Historical and Cultural District (Taiyuan Soviet Experts' Building) covers an area of approximately 7.21 hectares. It consists of 10 surviving historical buildings, showcasing the typical layout of residential areas in northern China in the 1950s. It is similar to the Mining Dormitory, as it retains Soviet-style architecture, blends politics with art, and combines classical and modern elements.

2.2. Questionnaire and Interview Design

The survey questionnaire was divided into three sections. The first section covered basic information and personal evaluations, including gender, birth year, identity, and length of residence. The second section focused on soundscape perception and overall environmental evaluation. Soundscape perception included two dimensions: soundscape preference and soundscape perception frequency. A 5-point linear scale was used for the questionnaire: 1—Strongly dislike/Not at all, 2—Dislike/A little, 3—Moderately, 4—Like/A lot, and 5—Strongly like/Dominates completely. Participants were also required to evaluate the acoustic environment, housing conditions, life satisfaction, and neighborhood features. Subjective evaluations for overall environment were conducted using a 5-point linear scale corresponding to acoustic satisfaction evaluations (1—Very bad, and 5—Very good). The third section comprised the sense of place scale, which employed a Likert 5-point scale for evaluation (1—strongly disagree, and 5—strongly agree). This study investigated the sense of place in terms of both place attachment and place identity. Referring to the classic scale designed by Daniel R. Williams and Jerry J. Vaske in 2003 [38], and subsequently adjusting and refining it based on the specific circumstances of Taiyuan's historical cultural areas, a total of eight items were included (Table 1).

Table 1. Scale for sense of place.

Code	Place Attachment	Code	Place Identity
Y1	The feeling I get here is unmatched by other places	R1	I am concerned about the development and preservation here
Y2	I am willing to live here for a long time	R2	This place means a lot to me
Y3	Living here makes me happy	R3	This place is very special to me
Y4	I take pride in living here	R4	This place is a part of me

The purpose of the interviews was to explore residents' perspectives on place attachment and the development of place identity by referencing different environmental dimensions. Sample questions included: "If you had the opportunity to remove your home, would you want to? What are the reasons for wanting or not wanting to do so?" and "What environmental conditions (including sounds) are the most difficult for you to part with?" Additionally, the interviews included general questions, providing participants with the opportunity to discuss any aspects of the environment and sense of place not covered in the questionnaire. All interviews were recorded with participants' consent and subsequently transcribed. Grounded theory was then employed to condense and refine the interview text. The procedural coding theory by Strauss and Corbin guided open coding, axial coding, selective coding, and other steps in the analysis process [39]. The complete interview content can be found in Appendix A.

2.3. Field Survey and Data Collection

2.3.1. Field Survey

In the preliminary stage of this research, the soundwalk method was employed to investigate the acoustic environment of residents' activity locations. Twenty undergraduate and graduate students with good hearing and cognitive levels were selected, with ages ranging from 20 to 26 years old. The survey was conducted in September 2023, during clear daytime weather. Measurements were sequentially taken in the four districts, recording all observational results. Subsequently, based on the classification criteria defined in ISO 12913-2:2018 [40], a total of 25 types of sound sources surveyed were categorized into 11 categories under three major classes (Table 2).

Table 2. Soundscape composition.

	Category	Sound Source
Sounds of technology	Traffic Sounds (TS)	Car Horns and Engine Noises
	Commercial Sounds (CS)	Shop Loudspeaker Sounds
Sounds of nature	Natural Phenomenon Sounds (NPS)	Wind Sounds, Rustling Leaves, Rain Sounds, and Thunder Sounds
	Birdsong and Insect Sounds (BIS)	Birdsong and Insect Chirping
	Water Sounds (WS)	Flowing Water Sounds and Fountain Sounds
	Pet Sounds (PS)	Dog Barking
Sounds of human beings	Leisure Activity Sounds (LAS)	Square Dancing Music, Singing, and Instrumental Sounds
	Entertainment Activity Sounds (EAS)	Chess Playing Sounds and Card Playing Sounds
	Traditional Commercial Sounds (TCS)	Street Vendor yells and Handcrafting Sounds
	Traditional Activity Sounds (TAS)	Traditional Opera Sounds and Twisting Yangko Sounds
	Daily Life Sounds (DLS)	Conversations and Children's Play

After completing the soundwalk measurements, the researchers utilized the Model S5671B sound level meter to measure the SPL in the field where residents stayed and engaged in activities within the districts. The measurement periods were divided into non-working days from 16:00 to 18:00 and working days from 9:00 to 17:00 to reflect the variations in the neighborhood's acoustic environment at different times. Each measurement

point underwent three consecutive measurements on non-working days and working days, respectively. Each measurement lasted for 1 min, recording the equivalent continuous A-weighted sound level (L_{Aeq}). The sound level meter was placed approximately 1.2 m above the ground and at least 1 m away from any sound source.

2.3.2. Questionnaire Data Collection

The questionnaire survey and semi-structured interviews were conducted simultaneously from September to November 2023, selecting days with good weather conditions. During the daytime, hearing-adequate residents were randomly selected in the research area for interviews. The questionnaire surveys and interviews were conducted in outdoor, comfortable environments. Each questionnaire survey lasted approximately 5 min. Before the respondents filled out the questionnaire, the interviewer explained the concepts or meanings of each question and ensured that the respondents understood the meaning of each question. This allowed them to answer the questionnaire based on their current environmental experiences. Among the four historical and cultural areas, the largest one had 2100 registered households, while the smallest one only had 280. After determining the different sampling intervals for different districts, a sample size of 350 was established based on sampling principles. During the field investigation, the number of samples was increased due to the validity of the questionnaire and practical difficulties, and a total of 373 participants were randomly selected for this study. A total of 373 questionnaires were distributed in four areas, with 354 valid responses, resulting in an effective rate of 95%. The basic information of the respondents is summarized in Table 3. The gender distribution of respondents was balanced, with 45.5% male and 54.5% female. Local residents constituted 74% of the respondents, while tenants accounted for 26%. Middle-aged and elderly respondents (45 years and above) made up 76.3% of the participants.

After the questionnaire survey concluded, semi-structured, in-depth interviews were conducted with 81 residents from four historical and cultural areas who expressed a willingness to engage in further discussions, focusing on sound and perceptions. These districts have a history of construction spanning over 70 years, with the majority of residents being middle-aged or elderly. With the precondition of ensuring participants did not experience fatigue, the average duration of each interview was 15 min. Participants could answer questions during the interviews based on memory as well as their current environment. Among the interviewees, those under 18 years old accounted for 7.4%, those aged 18–44 accounted for 22.2%, middle-aged individuals (45–65 years old) constituted 42.0%, and seniors over 65 years old made up 28.4%. Native residents were more willing to participate in in-depth interviews compared to tenants. The interview content covered perceptions of soundscapes and the connection between soundscapes and sense of place. A total of 176,000 words of interview text were compiled.

Table 3. Basic information survey of respondents.

Projects		Questionnaire Participants		Interview Participants	
Gender	female	193	54.5%	43	53.1%
	male	161	45.5%	38	47.0%
Age	>65	120	33.9%	23	28.4%
	45–65	150	42.4%	34	42.0%
	18–44	71	20.0%	18	22.2%
	<18	13	3.7%	6	7.4%
Status	native residents	262	74.0%	70	86.4%
	tenants	92	26.0%	11	13.6%
Length of residence (year)	>20	176	49.7%	42	51.9%
	10–20	58	16.4%	16	19.8%
	5–10	48	13.6%	12	14.8%
	1–5	42	11.9%	9	11.0%
	≤1	30	8.4%	2	2.5%

2.4. Data Analysis

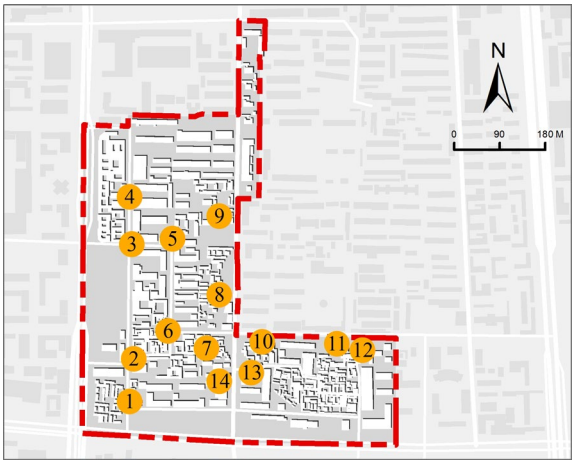
To identify types of sound sources and assess the quality of neighborhood soundscapes, this paper conducted physical environment measurements. Descriptive analysis using SPSS 26 software was utilized to characterize residents' perceptions of soundscapes, personal evaluations, and levels of sense of place. Validity analysis, reliability analysis, and Spearman correlation analysis for the scales were also conducted, revealing potential associations between these variables. Additionally, Amos 24 software was utilized to construct a structural equation model, further exploring the multifactorial relationships between soundscapes' perceptions, personal evaluations, and sense of place. This provided robust support for the construction of the theoretical model.

To supplement the quantitative analysis with overlooked soundscape information in the research area and gain a comprehensive understanding of the impact mechanism of soundscapes on sense of place, qualitative analysis was conducted using NVivo 11 software. Qualitative research can be built on the foundation of grounded theory, and cross-validated and complemented with quantitative data. This qualitative analysis helped uncover residents' subjective experiences and detailed nuances in the perception of soundscapes and sense of place. Compared to quantitative data, it provided an alternative perspective for interpretation.

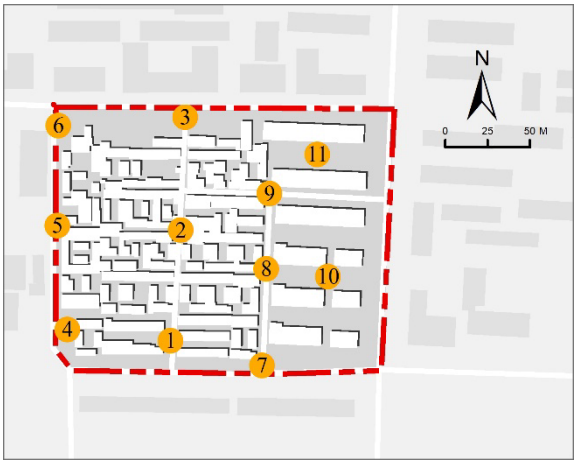
3. Results

3.1. Acoustic Environment Measurement Results

The arrangement of measurement points in the four neighborhoods is illustrated in Figure 2. Layout diagram of measurement points: (a) Nanhuamen District; (b) Dongsandao Lane; (c) Taiyuan Mining Machinery Factory Dormitory; and (d) Taiyuan Soviet Experts' Building. The results of the acoustic environment measurements (Table 4) reveal specific differences in sound pressure levels between non-working days and working days in the historical and cultural areas.



(**a**)



(**b**)

(**c**) (**d**)

Figure 2. Layout diagram of measurement points: (**a**) Nanhuamen District; (**b**) Dongsandao Lane; (**c**) Taiyuan Mining Machinery Factory Dormitory; and (**d**) Taiyuan Soviet Experts' Building. The numbers in the figure indicates the measurement locations for acoustic environment.

Referring to ISO-1996-1's typical level adjustments based on sound source category and time of day [41], China sets the residential area's daytime noise standard at 55 dB, according to specific circumstances. From the measurement outcomes, it was observed that on non-working days, 40 out of 50 measurement points in the four neighborhoods complied with the residential area's daytime noise standard, while 10 points exceeded the standard limits. On working days, 46 out of 50 measurement points met the standards, with 4 points exceeding the standard limits. The factors contributing to elevated sound pressure levels or exceeding the standard range at certain measurement points included broadcast noise from shops and promotional booths, as well as traffic noise and residential activity sounds.

Table 4. Sound pressure level measurement data for four districts.

	Equivalent Continuous A-Weighted Sound Level on Non-Working Days (dB(A))			**Equivalent Continuous A-Weighted Sound Level on Working Days (dB(A))**		
	Max	**Min**	**Avg**	**Max**	**Min**	**Avg**
Nanhuamen District	64.4	54.1	59.3	70.3	49.6	58.2
Dongsandao Lane	59.6	51.7	55.3	62	49.9	53.6
Taiyuan Mining Machinery Factory Dormitory	73.8	51.6	57.9	65.6	44.0	55.5
Taiyuan Soviet Experts' Building	70.1	46.4	55.4	72.5	42.5	53.0

3.2. Questionnaire Reliability Analysis and Validity Analysis

3.2.1. Reliability Analysis

Quality inspection of questionnaire data is a crucial prerequisite to ensure the subsequent analysis is meaningful. Internal consistency for each dimension was analyzed using the Cronbach's alpha coefficient reliability test method in SPSS 26 software. The results of the reliability analysis in this study are presented in Table 5. Generally, reliability coefficients between 0.6 and 0.7 are considered acceptable, between 0.7 and 0.8 are considered moderately reliable, and between 0.8 and 0.9 are considered highly reliable. The scales utilized in this research demonstrate excellent internal consistency, indicating good reliability [42].

Table 5. Reliability analysis results.

	Cronbach's Alpha Coefficient	Number of Items
Soundscape Preference	0.716	11
Soundscape Perception Frequency	0.731	11
Personal Evaluation	0.610	7
Place Attachment	0.829	4
Place Identity	0.805	4

3.2.2. Validity Analysis

SPSS 26 software was employed to conduct Bartlett's sphericity test and the Kaiser–Meyer–Olkin (KMO) test for the scale. The results, as shown in Table 6, indicated a significance level of 0.000 ($p < 0.001$) for Bartlett's sphericity test, confirming that the data passed the test. The KMO value was 0.778 (KMO > 0.60), indicating good validity of the scale. The analysis results confirmed the structural validity of the scale. The collected data were suitable for factor analysis [43].

Table 6. Bartlett's sphericity test and KMO test.

Variable		Soundscape Preference	Soundscape Perception Frequency	Personal Evaluation	Sense of Place	Overall Test
Kaiser–Meyer–Olkin measure of sampling adequacy		0.742	0.732	0.716	0.874	0.778
Bartlett's Sphericity Test	Approximate Chi-Square	516.162	737.476	448.752	1123.05	3718.09
	Degrees of Freedom	55	55	21	28	666
	Significance	0.000	0.000	0.000	0.000	0.000

3.3. Descriptive Statistics of Soundscape Perception, Personal Evaluation, and Residents' Sense of Place

3.3.1. Descriptive Statistics of Residents' Soundscape Perception Assessment

The perceptual aspect of the soundscape included overall environmental evaluation and typical soundscape perception. The average rating for residents' acoustic environmental evaluation was 3.44, indicating that residents generally approved of the neighborhood's acoustic environment. More than half (52.3%) of the respondents expressed satisfaction or high satisfaction with the soundscapes, demonstrating that it met the expectations of the majority of surveyed residents. The characteristics of residents' soundscape perception are illustrated in Figure 3. In terms of preferences for soundscapes, residents showed the highest preference for water sounds (3.75) and birdsongs/insect sounds (3.71), followed by traditional activity sounds (3.55). The least preferred sounds were traffic sounds (2.31), commercial sounds (2.52), and pet sounds (2.61). Regarding the soundscape perception frequency, traffic sounds (2.76) had the highest perception frequency, followed by daily life sounds (2.58), commercial sounds (2.45), and pet sounds (2.4). This indicates that human activities significantly influence the predominant sound in the area.

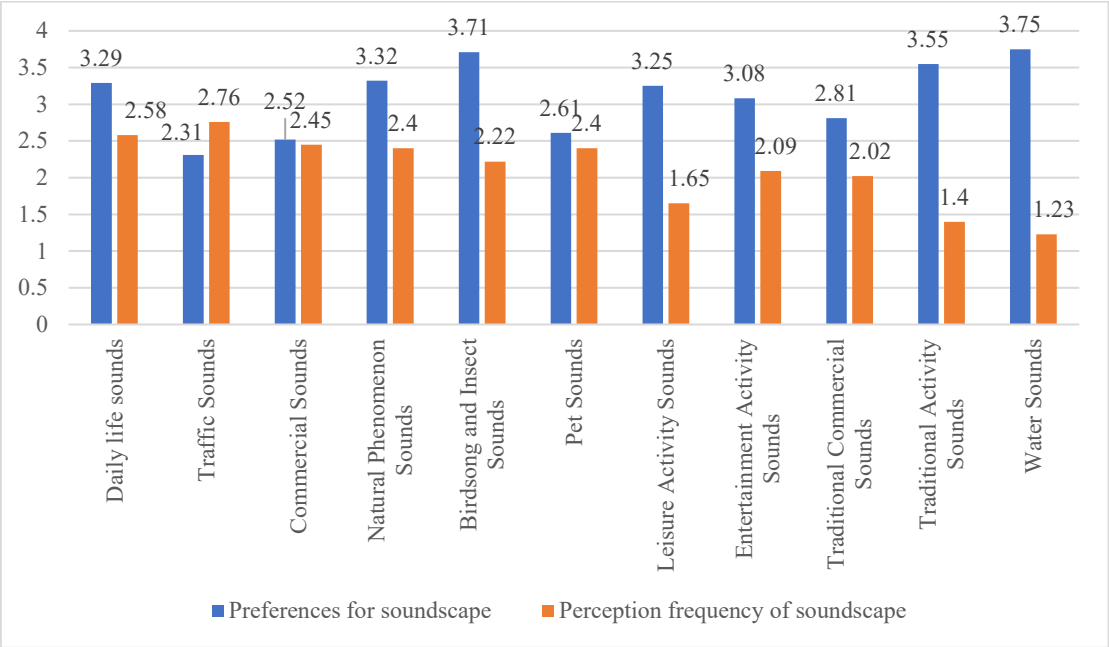


Figure 3. Statistics of residents' perception evaluation of soundscapes.

3.3.2. Descriptive Statistics of Personal Evaluation

The descriptive statistics of personal evaluations are illustrated in Figure 4. In the evaluation of the historical and cultural areas, residents provided an average rating of 2.76 for their understanding of the district's history. The degree of neighborhood features scored 2.65, and the evaluation of cultural preservation scored 3.08, indicating a relatively low degree. A significant proportion of residents, namely 23.4%, 25.7%, and 27.6%, selected responses indicating "completely unaware", "lacking distinctiveness", or "poor/very poor preservation."

Despite the relatively intact preservation of historical buildings in the four districts, residents perceived a high level of cultural preservation. However, they also expressed the belief that the overall appearance and ambiance of the districts had undergone changes, to some extent losing their original characteristics. Residents self-assessed their knowledge of the district's history with an average rating of only 2.76, indicating a limited understanding of the district's history.

Residents provided average ratings above 3 for all four questions related to the living environment. The average score for housing condition evaluation was 3.03, overall environment evaluation was 3.35, and life satisfaction averaged 3.69. Overall, residents' evaluations of housing conditions, neighborhood environment, and life satisfaction are positive, although the average scores fall below 4, indicating a level that is not considered good or very satisfactory.

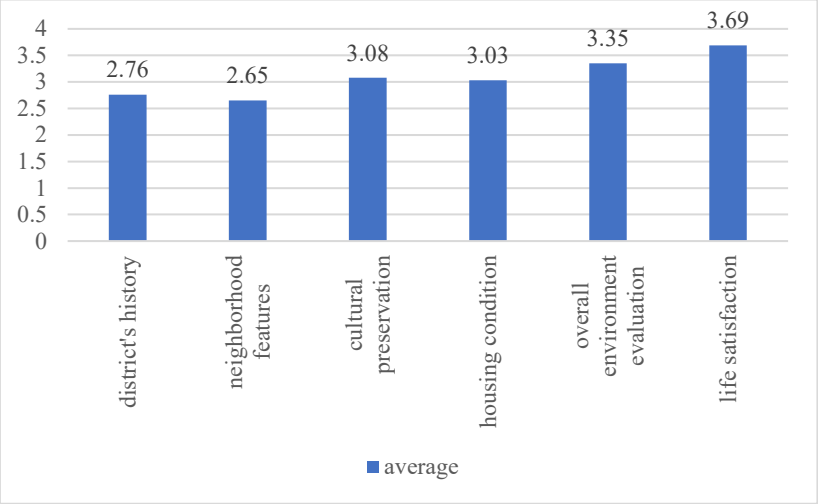


Figure 4. Evaluation of historic cultural district and residential environment.

3.3.3. Level of Sense of Place

A statistical analysis was performed on the data from the residents' sense of place questionnaire. The average scores of Y1–Y4 were used to measure the level of place attachment, while the average scores of R1–R4 were used to measure the level of place identity. The residents' level of place identity (average score of 3.48) was slightly higher than the level of place attachment (average score of 3.40).

The average scores for each item are calculated separately, and the results are depicted in Figure 5. Residents exhibited the highest level of agreement with the "R4" indicator, with an average score of 3.59, followed by "Y3 (3.57)", "R1 (3.55)", and "R2 (3.46)." All item scores averaged above 3, indicating positive responses for each item.

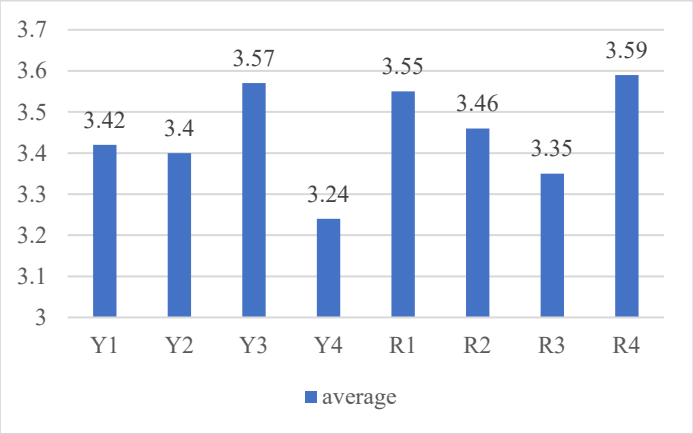


Figure 5. Statistics of sense of place evaluation.

3.4. Correlation Analysis of Soundscape Perception, Personal Evaluation, and Sense of Place

The Spearman's rank correlation coefficient method was employed in SPSS 26 software to examine whether there were statistical associations between the preference, perception frequency, and personal evaluation of typical soundscapes with place attachment and place identity. The results are presented in Table 7.

Table 7. Correlation analysis results of soundscape perception, personal evaluation, and sense of place.

	Soundscape Preference	Soundscape Perception Frequency	Personal Evaluation
Place Attachment	Daily life Sounds (0.157 **) Commercial Sounds (0.144 *) Leisure Activity Sounds (0.174 **) Traditional Commercial Sounds (0.241 **) Traditional Activity Sounds (0.157 **)	Daily life Sounds (0.175 **) Leisure Activity Sounds (0.115 *) Entertainment Activity Sounds (0.227 **) Traditional Activity Sounds (0.187 **)	Level of Historical Understanding (0.204 **) Level of Neighborhood Features (0.267 **) Level of Cultural Preservation (0.316 **) Housing Condition Evaluation (0.257 **) Overall Environment Evaluation (0.318 **) Life Satisfaction (0.401 **) Acoustic Environment Evaluation (0.232 **)
Place Identity	Leisure Activity Sounds (0.156 **) Traditional Commercial Sounds (0.128 **) Traditional Activity Sounds (0.125 *)	Daily life Sounds (0.123 *)	Level of Historical Understanding (0.418 **) Level of Neighborhood Features (0.294 **) Level of Cultural Preservation (0.221 **) Overall Environment Evaluation (0.114 *) Life Satisfaction (0.217 **)

** At the 0.01 level (two-tailed), the correlation is significant. * At the 0.05 level (two-tailed), the correlation is significant.

In terms of place attachment and place identity, preferences for leisure activity sounds, traditional commercial sounds, and traditional activity sounds were positively correlated with place attachment (0.174 **, 0.241 **, and 0.157 **) and place identity (0.156 **, 0.128 **, and 0.125 *). Daily life sounds and commercial sounds were positively correlated with place attachment (0.157 ** and 0.144 *) but not significantly related to place identity. In terms of the perception frequency of soundscapes, daily life sounds were positively correlated with both place attachment (0.175 **) and place identification (0.123 **). Leisure activity sounds, entertainment activity sounds, and traditional activity sounds were positively correlated with place attachment (0.115 *), (0.227 **), and (0.187 **), respectively, while the relationship with place identity was not significant.

Historical understanding, neighborhood features, cultural preservation, overall environmental evaluation, and life satisfaction in personal evaluations were all positively correlated with place attachment (0.204 **, 0.267 **, 0.316 **, 0.318 **, and 0.401 **) and place identity (0.418 **, 0.294 **, 0.294 **, 0.221 **, 0.114 **, and 0.217 **). Housing conditions and acoustic environment evaluations were positively correlated with place attachment (0.257 ** and 0.401 **) but not significantly related to place identification.

3.5. Structural Equation Model of Soundscape Perception and Sense of Place

3.5.1. Exploratory Factor Analysis

Based on Bartlett's Test of Sphericity ($p < 0.001$, test result 0.000) and the KMO value (KMO > 0.60, test result 0.778), the analysis of the dataset validity for the factor analysis of the needs measured by the questionnaire demonstrated the possibility of establishing structural equation modeling (SEM) for soundscape perception and sense of place [26].

The dimensions of soundscape preference, perception frequency, and personal evaluation were delineated through exploratory factor analysis (EFA).

- For the EFA of soundscape preference:

Conducted through principal component analysis, the rotated component matrix results, as shown in Table 8, revealed three common factors for soundscape preference, with a cumulative explained variance of 56.269%. These three common factors were as follows:

Special Activity Sound Preference (P1): Including "Leisure Activity Sounds", "Entertainment Activity Sounds", "Traditional Commercial Sounds", and "Traditional Activity Sounds", this factor explained 20.367% of the variance. It primarily reflects residents' preferences related to activities and longstanding residential traditions.

Life Background Sound Preference (P2): Including "Daily life Sounds", "Commercial Sounds", "Traffic Sounds", and "Pet Sounds", this factor explained 18.499% of the variance. It is mainly associated with the background sounds in the current residential area and they hold a significant share in residents' daily lives.

Natural Sound Preference (P3): Including "Natural Phenomenon Sounds", "Birdsong and Insect Sounds", and "Water Sounds", this factor explained 17.403% of the variance. It primarily relates to natural sounds in the neighborhood environment.

Table 8. Component matrix after rotation of soundscape preference scale.

	Component		
	1	**2**	**3**
P-DLS	0.319	0.484	0.186
P-TS	−0.073	0.759	−0.026
P-CS	0.215	0.706	0.024
P-NPS	0.032	0.182	0.676
P-BIS	0.058	0.162	0.76
P-PS	−0.017	0.454	0.312
P-LAS	0.767	0.08	−0.134
P-EAS	0.632	0.171	0.065
P-TCS	0.494	0.397	0.221
P-TAS	0.661	−0.082	0.357
P-WS	0.439	−0.205	0.573
Eigenvalues	2.023	1.334	1.186
Variance explained	20.367%	18.499%	17.403%
Cumulative explained variance	20.367%	38.866%	56.269%

The dark-colored areas in the table represent the factors included in each component respectively.

- For the EFA of soundscape perception frequency:

As shown in Table 9, following the exploratory factor analysis (EFA), three common factors were extracted from the soundscape perception frequency scale, with a cumulative explained variance of 58.6%. These three common factors were:

Soundscape perception frequency with a large discrepancy between current and expected sounds (LI): This factor included "Leisure Activity Sound Perception Frequency", "Water Sound Perception Frequency", and "Traditional Activity Sound Perception Frequency", explaining 25.636% of the variance. Residents have high expectations for the soundscape preference in this factor, but the actual situation exhibits a lower soundscape perception frequency.

Soundscape perception frequency with a moderate discrepancy between current and expected sounds (L2): This factor included "Daily life Sound Perception Frequency", "Birdsong and Insect Sound Perception Frequency", "Entertainment Activity Sound Per-

ception Frequency", and "Natural Phenomenon Sound Perception Frequency", explaining 17.882% of the variance. The sounds in this factor have a relatively smaller gap between the actual situation and expectations.

Soundscape perception frequency with minimal discrepancy between current and expected sounds (L3): This factor included "Commercial Sound Perception Frequency", "Traditional Commercial Sound Perception Frequency", "Traffic Sound Perception Frequency", and "Pet Sound Perception Frequency", explaining 15.082% of the variance. This type of soundscape perception frequency encompasses numerous noise sources that impact residents' lives, and residents express more dissatisfaction with this factor. Its current situation is at the highest point.

Table 9. Component matrix after rotation of soundscape perception frequency scale.

	Component		
	1	**2**	**3**
F-DLS	0.059	0.675	0.049
F-TS	−0.17	0.292	0.544
F-CS	0.061	0.175	0.763
F-NPS	0.249	0.582	0.055
F-BIS	0.168	0.632	0.173
F-PS	−0.008	0.185	0.573
F-LAS	0.69	0.186	0.154
F-EAS	0.328	0.589	0.054
F-TCS	0.194	−0.013	0.772
F-TAS	0.86	0.109	0.005
F-WS	0.855	0.138	0.074
Eigenvalues	2.313	1.515	1.394
Variance explained	25.636%	17.882%	15.082%
Cumulative explained variance	25.636%	43.518%	58.6%

The dark-colored areas in the table represent the factors included in each component respectively.

- For the EFA of personal evaluations:

As shown in Table 10, the EFA factor analysis of personal evaluations yielded a total of two common factors, with a cumulative explained variance of 57.337%.

Residential environment evaluation (J1): This factor included "Housing Condition Evaluation", "Overall Environment Evaluation", "Life Satisfaction", and "Acoustic Environment Evaluation", explaining 35.343% of the variance. Factor 1 is primarily associated with the subjective evaluation of the physical environment of residence, encompassing specific aspects such as the built environment and acoustic environment.

Neighborhood evaluation (J2): Including "Level of Historical Understanding", "Level of Neighborhood Features", and "Degree of Cultural Preservation", this factor explained 21.994% of the variance. Factor 2 is mainly linked to the subjective evaluation of historical and cultural characteristics of the historical and cultural areas, emphasizing the recognition of the unique value of historical cultural neighborhoods.

Table 10. Component matrix after rotation of personal evaluation scale.

	Component	
	1	**2**
E-HC	0.782	−0.038
E-OE	0.834	−0.038
E-LS	0.753	0.017
E-AE	0.617	0.163
E-LHU	−0.236	0.637

E-LNF	0.085	0.84
E-LCP	0.395	0.632
Eigenvalues	2.442	1.571
Variance explained	35.343%	21.994%
Cumulative explained variance	35.343%	57.337%

The dark-colored areas in the table represent the factors included in each component respectively.

3.5.2. Confirmatory Factor Analysis

The construct validity of the relationship between observed variables and latent variables was tested through CFA. The results in Table 11 showed that all observed variables had good convergent validity (standardized factor loading ≥ 0.5, AVE ≥ 0.5, CR ≥ 0.6), and the constructs had good discriminant validity (MSV < AVE, ASV < AVE).

The calculation formulas are as follows, where λ represents the factor loading:

AVE:

$$l_{AVE} = \frac{(\sum \lambda^2)}{N} \quad (1)$$

CR:

$$l_{CR} = \frac{(\sum \lambda)^2}{[(\sum \lambda)^2 + \sum \varepsilon]} \quad (2)$$

Table 11. Convergent validity and composite reliability test for various dimensions of local sentiment scale.

Latent Variable	Observed Variables	Std. Factor Loading	AVE	CR	MSV	ASV
Preference 1	P-LAS	0.602	0.513	0.807	0.345	0.246
	P-EAS	0.783				
	P-TCS	0.781				
	P-TAS	0.693				
Preference 2	P-DLS	0.604	0.507	0.801	0.425	0.302
	P-TS	0.622				
	P-CS	0.844				
	P-PS	0.755				
Preference 3	P-NPS	0.737	0.596	0.813	0.306	0.195
	P-BIS	0.669				
	P-WS	0.885				
Frequency 1	F-LAS	0.503	0.554	0.780	0.476	0.283
	F-TAS	0.824				
	F-WS	0.855				
Frequency 2	F-DLS	0.635	0.597	0.853	0.426	0.221
	F-NPS	0.856				
	F-BIS	0.674				
	F-EAS	0.893				
Frequency 3	F-CS	0.812	0.527	0.815	0.368	0.194
	F-PS	0.624				
	F-TS	0.762				
	F-TCS	0.701				
Evaluation 1	E-HC	0.721	0.587	0.850	0.468	0.216
	E-OE	0.758				
	E-LS	0.692				
	E-AE	0.884				
Evaluation 2	E-LHU	0.650	0.424	0.687	0.258	0.097

	E-LNF	0.612				
	E-LNF	0.688				
Place attachment	Y1	0.584	0.557	0.832	0.452	0.306
	Y2	0.755				
	Y3	0.842				
	Y4	0.784				
Place Identity	R1	0.551	0.543	0.822	0.472	0.275
	R2	0.848				
	R3	0.821				
	R4	0.690				

3.5.3. Establishment of Structural Equation Model

Based on the above research results, using the representing factors in Sections 3.5.1 and 3.5.2, the following assumptions were proposed:

H_A: Soundscape preference significantly influences place attachment and place identity. Specific hypotheses include:

H_{A1}: P1 has a positive impact on place attachment. H_{A2}: P1 has a positive impact on place identity. H_{A3}: P2 has a positive impact on sense of place attachment. H_{A4}: P2 has a positive impact on place identity. H_{A5}: P3 has a positive impact on sense of place attachment. H_{A6}: P3 has a positive impact on place identity.

H_B: Soundscape perception frequency significantly influences place attachment and place identity. Specific hypotheses include:

H_{B1}: F1 has a positive impact on place attachment. H_{B2}: F1 has a positive impact on place identity. H_{B3}: F2 has a positive impact on place attachment. H_{B4}: F2 has a positive impact on place identity. H_{B5}: F3 has a negative impact on place attachment. H_{B6}: F3 has a negative impact on place identity.

H_C: Personal evaluation significantly influences place attachment and place identity. Specific hypotheses include:

H_{C1}: E1 has a positive impact on place attachment. H_{C2}: E1 has a positive impact on place identity. H_{C3}: E2 has a positive impact on place attachment. H_{C4}: E2 has a positive impact on place identity.

A structural equation model was constructed based on three main hypotheses and sixteen specific hypotheses. The model was visually represented using AMOS 24 software (Figure 6). Parameter estimation was conducted using the maximum likelihood estimation method, yielding values for parameters such as x^2/df, GFI, CFI, and RMSEA, as shown in Table 12.

Both the GFI and CFI parameters did not meet the recommended values, indicating the need for model modification.

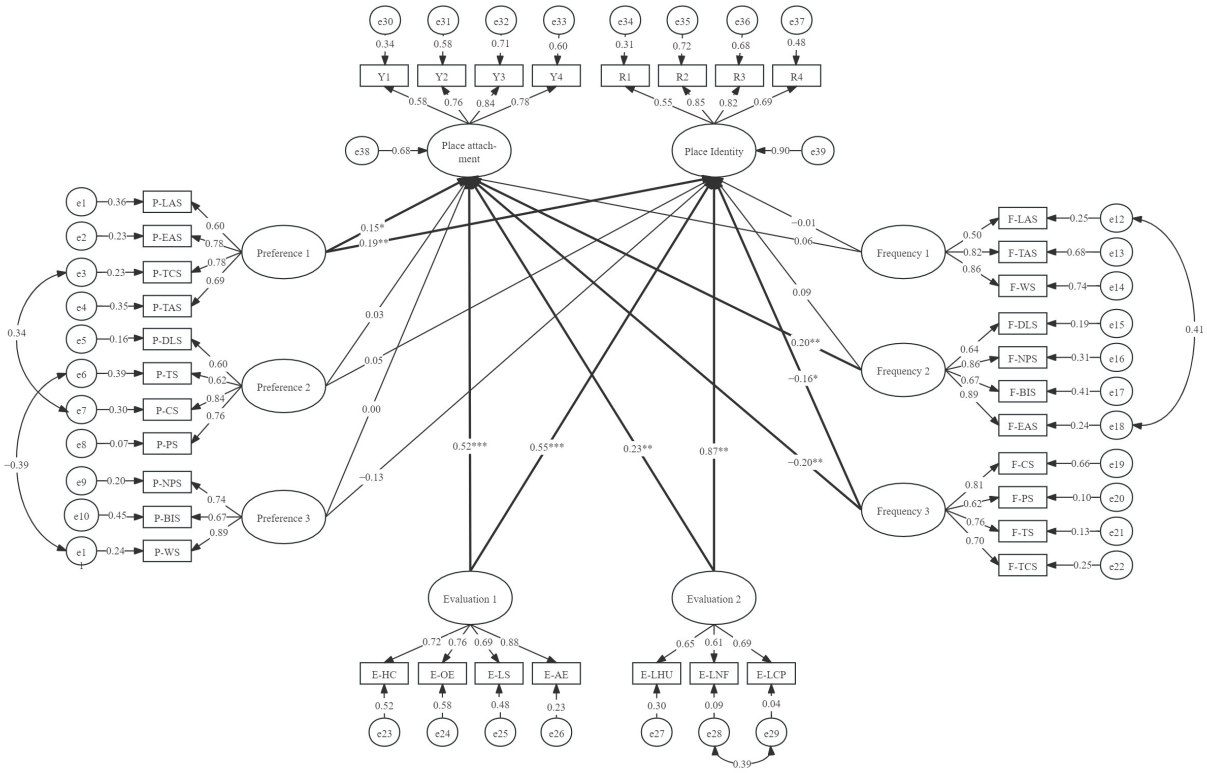


Figure 6. Structural equation model of the impact of soundscape perception on residents' sense of place. ***At the 0.001 level (2-tailed), **At the 0.01 level (2-tailed), *At the 0.05 level (2-tailed), the correlation is significant.

Table 12. Structural equation model fit test.

Indicator	Reference Standard	Result
CMIN/DF	Excellent: 1–3, Good: 3–5	1.934
RMSEA	Excellent: <0.05, Good: <0.08	0.054
GFI	Excellent: >0.9	0.801
TLI	Excellent: >0.9	0.806
CFI	Excellent: >0.9	0.830

The correction of the structural equation model primarily relied on the Modification Index (MI) values and t-values from the output results. Under the premise of logical model coherence, additional paths with significant MI values were introduced. The viability of these adjustments was assessed by comparing fit indices. To address the current model, correlations between the residuals of Preference 1 and Preference 2, as well as between the residuals of leisure activity sound and entertainment activity sound perception frequencies, were included. After iterative correction steps, the adapted GFI reached 0.90, indicating a well-fitting model with optimal structural parameters (Table 13).

Table 13. Revised model fit test.

Indicator	Reference Standard	Result
CMIN/DF	Excellent: 1–3, Good: 3–5	1.504
RMSEA	Excellent: <0.05, Good: <0.08	0.040
GFI	Excellent: >0.9	0.912
TLI	Excellent: >0.9	0.900
CFI	Excellent: >0.9	0.909

3.5.4. Structural Equation Model Results

The results of the model path relationship examination are presented in Table 14. The table selectively showed significant paths. Paths H_{A1}, H_{A2}, H_{B3}, H_{B5}, H_{B6}, H_{C1}, H_{C2}, H_{C3}, and H_{C4} were significant, while other paths were not. Specifically, at the level of soundscape preference, P1 had a significant positive impact on both place attachment and place identity.

At the level of soundscape perception frequencies, F2 significantly positively influenced place attachment, while F3 had a significant negative impact on both place attachment and place identity.

Regarding personal evaluations, both E1 and E2 had a significant positive impact on both place attachment and place identity.

Table 14. Results of structural equation model path significance tests.

	Path			Estimate	C.R.	P
H_{A1}	Place Attachment	←	Preference 1	0.155	2.334	0.02
H_{A2}	Place Identity	←	Preference 1	0.189	2.738	0.006
H_{B3}	Place Attachment	←	Frequency 2	0.203	2.931	0.003
H_{B5}	Place Attachment	←	Frequency 3	−0.204	−3.117	0.002
H_{B6}	Place Identity	←	Frequency 3	−0.158	−2.474	0.013
H_{C1}	Place Attachment	←	Evaluation 1	0.515	5.609	<0.001
H_{C2}	Place Identity	←	Evaluation 1	0.227	3.453	<0.001
H_{C3}	Place Attachment	←	Evaluation 2	0.555	2.826	0.005
H_{C4}	Place Identity	←	Evaluation 2	0.873	2.803	0.005

3.6. Qualitative Analysis and Results

To compensate for the limits in quantitative analysis, this study employed qualitative analysis and grounded theory to systematically summarize and distill experimental methods and research, forming a deeper understanding.

The interview content covered residents' basic information and issues related to soundscape perception and its connection to sense of place. Firstly, a preliminary organization and numbering system was applied to the transcribed interviews, using A, B, C, and D to represent the historical and cultural areas of Taiyuan Soviet Experts' Building, Taiyuan Mining Machinery Factory Dormitory, Dongsandao Lane, and Nanhuamen District, respectively. Secondly, nodes were established by extracting content related to the emotional aspect of sense of place from the text, resulting in a total of 813 marked instances, with 638 specifically related to sounds. These 638 instances were then numbered; for example, if Text A1 extracted 36 reference points, they were sequentially coded as A1-01 to A1-36. This numbering process was consistently applied across all instances.

3.6.1. Open Coding

During the open coding phase, emotionally charged descriptive statements were distilled to form preliminary concepts. Subsequently, through comparison, supplementation, and consolidation, statements were categorized based on the characteristics of these preliminary concepts, leading to the abstraction and naming of categories. This entire process was repeated twice, resulting in 603 statements that were consistently coded in both iterations, constituting 94.51% of all statements. The high repetition rate suggests the reliability of the coding results. In total, 43 concepts and 12 categories are identified through this coding, with examples of open coding provided in Table 15.

Table 15. Partial examples of open coding.

Code	Original Statement	Conceptualization	Categorization
A1-05	Hearing the traditional singing reminds me of the festive activities organized in the 1980s.	Traditional activities memories	Memories of scenes
B1-23	Picking up my child from school and seeing the street vendors shouting, selling candied hawthorns, brings back memories of our lively childhood.	Memories of life scenes	Memories of scenes
B1-15	Hearing the pigeons outside the window makes me feel immersed in it, giving a sense of familiarity with my hometown.	Familiarity with hometown	Belonging
A2-07	Back when the factory celebrated the Chinese New Year, they would hang various kinds of lights. Since that part moved away, it's not as lively as before.	Desolate environment	Negative emotions
B2-12	The sound environment here is quite good, much better than before. Isn't there some exercise equipment? Listening to the sound of exercise makes me feel happy.	Feeling satisfied	Happiness
B2-26	The conversation among elderly people can make me feel the atmosphere of my hometown.	Human relationships	Emotional connection
B2-30	Sometimes when I come out and hear the sound of someone cooking, with the smell of them, this is the atmosphere of our community.	Cooking and buying groceries	Lifestyle
C1-06	Just coming out for a chat and enjoying the sun can make me feel the atmosphere of my hometown.	Leisurely life	Lifestyle
A2-03	So at that time, the company integrated cultures from various places, incorporating dialects. The sound here is a fusion of dialects, it's the local language.	Company culture, dialect	Regional culture
D1-08	If there are more plants and bird sounds here, the environment will be better. These sounds can enhance my feelings for this place.	Hope for a better environment	Imagining a vision

3.6.2. Axial Coding

Axial coding, building upon open coding, involves categorizing the existing codes and constructing the content of major categories through continuous comparisons between codes. Table 16 shows that a total of five major categories are identified, namely, memory, emotion, life, culture, and vision. Each major category encompasses various subcategories.

Table 16. Example of axial coding results.

Main Axis Coding	Open Coding		Reference Points
	Subcategories	Conceptualization	Mark Points
Memory	Memory of Scenes	Memory of traditional activities, Memory of production life scenes, Memory of leisure scenes, and Memory of entertainment scenes	80
	Memory of Relationships	Memory of old friends	9
	Historical Memory	Memory of neighborhood historical events	25
Emotion	Negative Emotions	Insufficient preservation, Excessive changes, Pessimism and disappointment, Harsh environment, Desolate environment, Thin human relationships, Dissatisfaction with the current situation, and Aversion to noise	167

	Positive Emotions	Bustling and lively, Good environment, Serene and peaceful, High quality, Happy and satisfied, Joyful and cheerful, and Proud	217
	Emotional Connection	Unique, Sense of belonging, Nostalgia, Social interactions, and Familiar habits	113
Life	Daily Labor	Housework, Cooking, and Grocery shopping	8
	Lifestyle	Work survival, Leisurely life, and Entertainment	101
Culture	Regional Culture	Folk customs and Factory culture	60
	Historical Culture	Cultural relics and Historical sites	13
	Cultural Fusion	Fusion from all areas	5
Vision	Vision and Imagination	Environmental imagination	15

Residents generated memories and visions through soundscape perception, both of which involved imagination of non-realistic scenarios. Memories consisted of three subcategories: memory of scenes, memory of relationships, and historical memory. The category of visions reflected residents' desires for the future and aspirations for life through soundscape perception.

The life category encompassed two subcategories: daily labor and lifestyle. Daily labor included conceptual dimensions such as shopping, housework, and cooking. Lifestyle was also a significant source triggering a sense of place and was divided into three conceptual dimensions: work survival, leisurely life, and entertainment.

The emotion category was divided into negative emotions, positive emotions, and emotional connections. Positive emotions referred to residents' relaxed, free, happy, and warm emotional responses during the perception of historical and cultural areas' soundscapes. This included conceptual dimensions such as bustling, happy and satisfied, serene and peaceful, and joyful and happy. Emotional connections represented residents' emotional attachment to others or things through soundscapes, including a sense of belonging, nostalgic feelings, and other conceptual dimensions. Negative emotions referred to residents' concerns and dissatisfaction triggered by soundscape perception, including insufficient preservation, excessive changes, dissatisfaction with the current situation, and other conceptual dimensions.

In the cultural category, three subcategories were identified: regional culture, historical culture, and cultural fusion. Regional culture was reflected in folk customs and factory culture. These texts also simultaneously reflected the subcategory of cultural integration. The historical culture subcategory manifested in residents' memories and understanding of the historical soundscapes of each historical and cultural area.

Based on the statistics of the number of place sense nodes triggered by soundscapes (Table 17), residents were most sensitive to traditional activity sounds, followed by leisure activity sounds, and were least sensitive to water sounds. In urban historical and cultural areas, leisure activity sounds and background sounds of daily life are common and more easily recognized by residents, thus triggering a sense of place. Natural sounds, as they are ambient sounds, attract less attention. Among the five main soundscapes, the order of trigger frequencies from highest to lowest was traditional activity sounds, leisure activity sounds, daily life sounds, entertainment activity sounds, and traditional commercial sounds.

Table 17. Soundscape triggering sense of place nodes statistics.

Main Axis Coding	Memory	Emotion	Life	Culture	Vision	Total
Traditional Activity Sounds	39	43	2	50	0	134
Traditional Commercial Sounds	8	50	0	1	5	64
Pet Sounds	0	33	0	0	0	33
Traffic Sounds	0	35	0	0	0	35

Birdsong and Insect Sounds	1	29	1	0	0	31
Daily life Sounds	11	61	13	6	6	97
Commercial Sounds	1	36	2	0	0	39
Water Sounds	0	2	0	0	0	2
Leisure Activity Sounds	6	52	40	0	4	102
Entertainment Activity Sounds	10	35	26	1	0	72
Natural Phenomena Sounds	1	28	0	0	0	29
Total	77	404	84	58	15	638

People tend to identify sounds within a category rather than individually [44]. After refining these five types of soundscapes, sounds were categorized based on their types, relying on common sense and life experience. The results are presented in the following Table 18:

Table 18. Historical and cultural area characteristic soundscape types.

Soundscape	Specific Sounds
Traditional Activity Sounds	New Year's Twisted Yangko Dance, Dragon Boat Racing, Drumming and Gongs, Stilt Walking, Firecrackers, Opera Singing, Lantern Hanging, Club Performances during the Spring Festival, and Fireworks Evening;
Traditional Commercial Sounds	Street Vendor yells, Fruit Stalls, Vegetable Stalls, Scrap Collection yells, Collecting Old Furniture, Collecting Appliances, Sharpening Chef's Knife, Candy Sellers, Snack Sellers, Fermented Rice Wine Sellers, Artisanal Craftsmanship, and Coal Ball Sellers;
Daily life Sounds	Daily Chatter, Coal Burning Sounds, School Opening, Cooking and Chopping Sounds, Children Playing Sounds, Friends Drinking, Chats on the Street, Mud Brickmaking, Exercise Sounds, Diverse Sounds of Bungalows, Monotonous Sounds of High-rises, Shanxi Dialect, Fusion of Various Dialects, Factory Singing Competitions, Cultural Events, and Neighborhood Committee Loudspeaker Sounds;
Leisure Activity Sounds	Badminton, Park Activity Sounds, Walking, Singing and Dancing, Brisk Walking, Tai Chi Practice, Square Dancing, Fitness Exercise, Jianzi Kicking, Playing Erhu, and Playing the Violin;
Entertainment Activity Sounds	Factory Club Entertainment, Playing Mahjong, Playing Poker, Chess, Watching Movies, Chess Room Activities, Factory Football Matches, Basketball Matches, and Glass Marbles Games;

Local traditions, customs, cultural integration from various regions, and the preservation of familiar daily life all contribute to the formation of a sense of place among residents in historical and cultural areas.

3.6.3. Selective Coding and Theoretical Saturation Testing

The final step in data analysis was selective coding. Following selective coding, a "mainline" was developed, where the core aspects that succinctly and predominantly explained the entire phenomenon were extracted from the initial conceptualization and categorization of the interview text material. Through multiple discussions and analyses of the initial conceptualization, categorization, and axial conceptualization results, the core category of "Dimensions of Place Attachment Implied by Soundscape" was eventually identified. Combined with the extraction of various categories and dimensions, this process collectively constructed a model illustrating the impact mechanism of the soundscape on the sense of place among residents in historical and cultural areas (Figure 7).

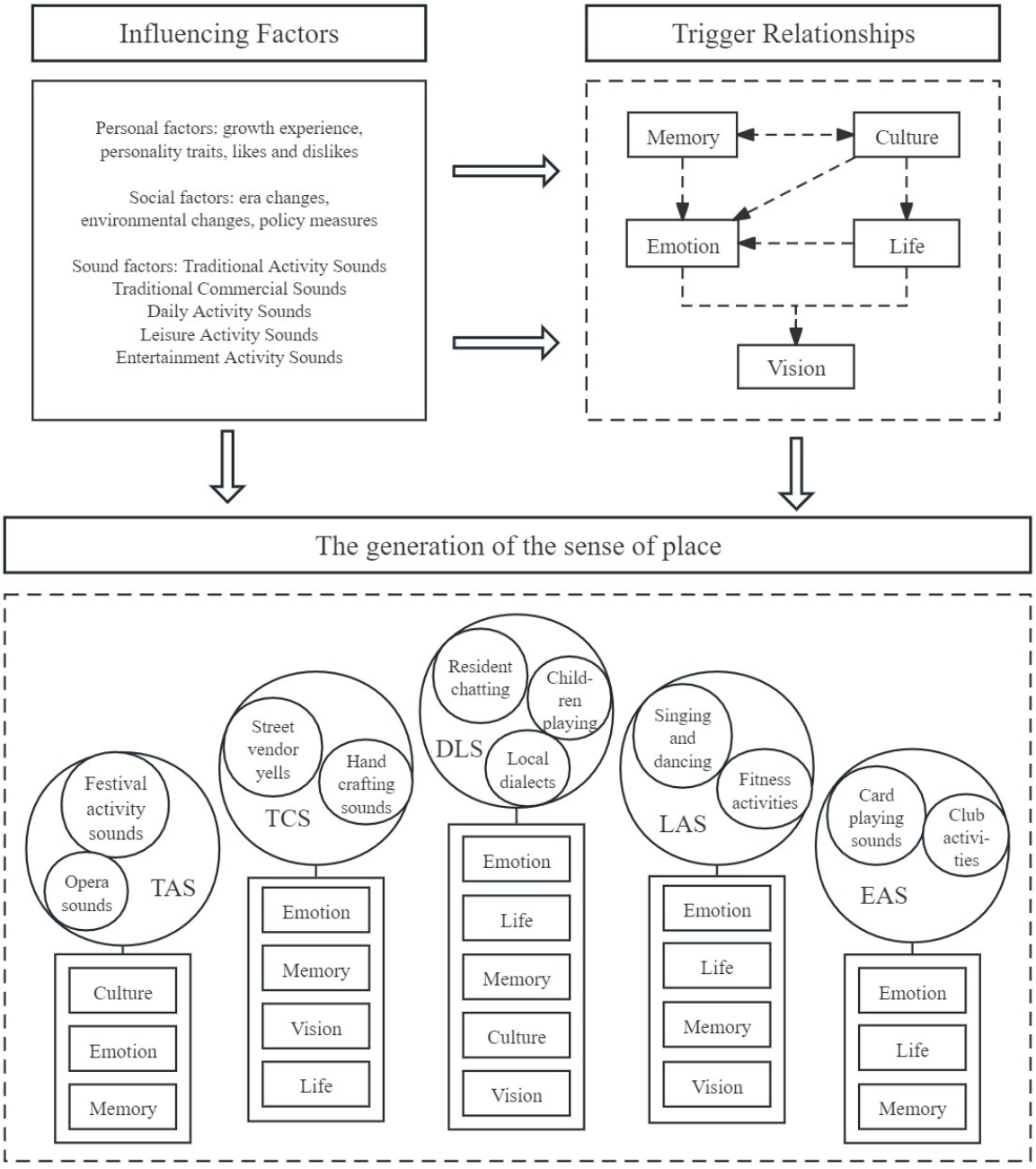


Figure 7. Mechanism model of the impact of the soundscape on residents' sense of place triggering.

Figure 7 shows that the sense of place is generated in individuals through the perception of a soundscape across five dimensions: memory, culture, emotion, lifestyle, and vision. As a medium for expressing the sense of place, the soundscape triggered residents' sense of place through traditional activity sounds, traditional commercial sounds, leisure activity sounds, entertainment activity sounds, and daily life sounds. The triggering mechanism and paths were influenced by personal factors such as growth experiences, personality traits, preferences, as well as societal factors like era changes, environmental variations, and policy measures. These factors contributed to variations in how individuals recognized and developed the sense of place across different dimensions. This study identified five pathways that summarized the generation of the sense of place triggered by a soundscape:

Soundscape Eliciting Memory Associations: all five types of soundscape could evoke a sense of place in this dimension, with traditional activity sounds, especially festive sounds, having a stronger impact;

Soundscape Enhancing Cultural Experience: traditional activity sounds exhibited the most significant effect on inspiring a cultural experience for the sense of place, while other soundscapes had relatively weaker effects;

Soundscape Triggering Emotional Connections: all five types of soundscape could evoke the sense of place in terms of interpersonal relationships and emotions, with no significant differences in strength;

Soundscape Maintaining Daily Life: residents' perception of their own life status was a crucial source of the sense of place, mainly influenced by daily life sounds, leisure activity sounds, and entertainment activity sounds;

Soundscape Prompting Imaginations of Place in Residents: this pathway, triggering imaginations about the neighborhood environment and social situations, mainly occurred due to the stimulation by traditional commercial sounds, daily life sounds, and leisure activity sounds, with no significant differences in strength.

Additionally, this study revealed causal and conditional relationships between these five dimensions of the sense of place stimulated by a soundscape: cultural experience could trigger memories and imaginations about cultural traditions; memory associations could also generate cultural experiences and emotional connections; cultural experiences, such as the formation of factory culture, positively affected the maintenance of life status; the residential living experience in the neighborhood generated emotional connections among residents; and positive visions and imaginations about the future, personal life, environment, and society could emerge through the association of daily life and emotional connections.

In this study, the random selection of original statements for re-coding using standard procedures resulted in a coding consistency that was essentially in line with the established categories. No new points or concepts were discovered, leading to the conclusion that the results were theoretically saturated.

4. Discussion

The acoustic environment measurements in residential historical and cultural areas revealed that, on non-working days, the average sound pressure levels were higher compared to working days, and there were more measurement points exceeding the standard limits. On non-working days, the district exhibited a lively and diverse atmosphere, with increased vehicular traffic, resident activities, and a variety of businesses, resulting in sound pressure levels higher than those on working days. The environmental noise exceeding standard limits in the district was primarily attributed to the loudspeaker sounds from shops and stalls, vehicular noise, and the activities of residents.

4.1. Factors Influencing Residents' Place Attachment in Residential Historical and Cultural Areas

The evaluation of soundscapes in historical and cultural areas was diverse, and the correlation analysis reflected positive relationships between the preference for daily life sounds, commercial sounds, the perception frequency of leisure activity sounds, traditional activity sounds, and place attachment. Both correlation analysis and structural equation modeling indicated significant positive relationships between the preference for special activity sounds (leisure activity sounds, traditional commercial sounds, and traditional activity sounds) and the soundscape perception frequency with a moderate discrepancy between current and expected sounds (daily life sounds and entertainment activity sounds) with place attachment. Koohsari's study found that place attachment was associated with physical activity and significantly correlated with the duration and likelihood of engaging in transportation and recreational activities within the community. Individuals with a high soundscape perception frequency tended to have a strong sense of place.

Places where individuals participated in specific and unique soundscapes together with other community members generated stronger place attachment than economic consumption places like large stores and cafes. Individuals with lower frequencies of visits to various community places tend to have lower levels of attachment to a particular place [45], which may explain the impact of residents' participation in activities on place attachment in residential historical and cultural areas. The special activities' sound is related to daily activities and community participation awareness. Environmentally friendly behaviors and high local participation are important ways to cultivate place attachment [46].

The structural equation model also demonstrated that the soundscape preference (entertainment activity sounds) and the soundscape perception frequency with a moderate discrepancy between current and expected sounds (natural phenomenon sounds and birdsong and insect sounds) positively predicted place attachment. Soundscape perception frequency with minimal discrepancy between current and expected sounds had a negative impact on place attachment, possibly related to the previously found negative impact of traffic noise on residential satisfaction [47], subsequently affecting residents' place attachment. Both correlation analysis and structural equation modeling results also indicated that neighborhood evaluation positively influenced residents' place attachment. Similar to the evaluations of tourists in historical and cultural areas, residents and tourists' positive evaluations of cultural heritage value and authenticity significantly contributed to place attachment [48]. The positive correlation between place attachment, resident participation, and environmentally friendly behavior dimensions studied by Irani may provide an explanation for this phenomenon [49]. This study also found that higher residential environment evaluation contributed to the formation of residents' place attachment. People's interest in the social dimension of place attachment has always been stronger than their interest in its physical dimension, but the perception of the physical environment can also contribute to place attachment.

The quantitative analysis results indicated that the preferences for some life background sounds (traffic sounds and pet sounds), preferences for natural sounds (natural phenomena sounds, birdsong and insect sounds, and water sounds), and the perception frequency of water sounds could not predict place attachment.

4.2. Factors Influencing Residents' Place Identity in Residential Historical and Cultural Areas

Only in the correlation analysis was it evident that the soundscape perception frequency with a moderate discrepancy between current and expected sounds (daily life sounds) could positively predict place identity. Both correlation analysis and structural equation modeling showed that the preferences for special activity sounds (leisure activity sounds, traditional commercial sounds, and traditional activity sounds) were significantly positively related to place identity. A unique, beautiful, comfortable, and tidy living environment was considered to contribute to providing social and sports activities, thereby promoting family life and residents' identification with the community [50]. Special activity sounds and daily life sounds enable residents to represent the community, thus psychologically triggering place identity, which aligns with previous research results by Brown. The structural equation model also indicated that the preference for entertainment activity sounds could positively predict place identity. However, the soundscape perception frequency with minimal discrepancy between current and expected sounds negatively predicted place identity, suggesting that the perception of such sounds may have impacted place identity similarly to its effect on residential satisfaction. The reason may be that people's minimal expected sound and noise overlap significantly, and noise is a major factor in choosing a place [51]. The research found that residents could form place identity through firsthand experiences, and individual activities were the result of practicing exercising subjectivity. Therefore, the preference for leisure activity sounds can facilitate residents' participation in activities, and the perception frequency of daily life sounds signifies the residents' involvement in daily activities, and both activities contribute to the formation of place identity.

The results of correlation analysis and structural equation modeling both indicated that the improvement in neighborhood evaluation promoted residents' place identity. Residential environment evaluation (overall environment evaluation and life satisfaction) positively predicted place identity. This confirmed the research conclusion of Escolà-Gascón: urban parks and greening levels can significantly enhance the sense of place, while noise exceeding 60 decibels can reduce the sense of place in cities [52]. In studies on tourist place attachment, previous research results indicated that tourists' perceived value can positively influence place identity [53]. Xu's research suggested that through the place conversions, tourists developed a sense of belonging and appreciation for architectural art, and were thus given meaning and developed place identity with the village [54]. In this study, the level of neighborhood features and cultural preservation in personal evaluations are part of cultural value, while overall environmental evaluations are part of quality value, and residents' perceived value similarly positively influences place identity from these aspects.

The quantitative analysis results showed that preferences for life background sounds and natural sounds, the soundscape perception frequency with a large discrepancy between current and expected sounds, and the soundscape perception frequency with a moderate discrepancy between current and expected sounds could not predict place identity.

4.3. The Mechanism of the Impact of Residential Historical and Cultural Areas' Soundscape on Residents' Sense of Place

As an important component of cultural landscape, the soundscape of historical and cultural areas refers to the acoustic environment perceived by people, which is a historical and culturally immersive sound impression, and its influence extends to the construction of residents' sense of place. The qualitative research text extracted from recordings was rich in residents' emotions, identification, and attachment to the place. On the one hand, soundscapes are considered a key medium for expressing a sense of place, manifesting shared memories and local culture, especially in the aspect of memory association [55]. On the other hand, soundscapes are a crucial factor in shaping the sense of place for residents in residential historical and cultural areas. Soundscapes meet residents' expectations and imagination of the place, establishing their attachment and identification. Social factors, personal factors, and soundscapes collectively contribute to the creation of the sense of place. The five main soundscapes that carried the sense of place in residential historical and cultural areas were traditional activity sounds, traditional commercial sounds, daily life sounds, leisure activity sounds, and entertainment activity sounds.

Within traditional activity sounds, festival activity sounds and traditional folk performance sounds mainly evoke residents' memories and emotional connections, adding to residents' cultural experiences to trigger a sense of place. In traditional commercial sounds, street vendors' yells and sounds of traditional craftsmanship inherit a rich historical culture, stimulating residents' childhood memories profoundly and triggering a sense of place. Daily life sounds include everyday conversations and children's playing sounds, and the interviews revealed that these diverse sounds trigger a sense of place from both life and emotional perspectives, also providing a source for residents' visions of a beautiful life. Uniquely, the formation of Taiyuan's historical and cultural areas bears traces of cultural fusion, and residents' dialects are a significant component of the sense of place, influencing it with human touch. Identity maintenance can be achieved through dialects [56]. Leisure activity sounds such as singing, dancing, and playing sports inject vitality and interest into the district, triggering a sense of place from life and emotional perspectives. Entertainment activity sounds like chess and poker game sounds, club entertainment sounds, and competition sounds organized in the district contribute to the district's cohesion and lively atmosphere.

In-depth insights from qualitative research indicated that soundscapes evoked residents' sense of place by triggering memories, connecting emotions, linking life, embodying culture, and creating visions. The most triggered aspect of soundscapes was emotional

connections, where emotions between individuals occurred within the objective geographical environment, serving as a crucial factor in triggering a sense of place. Besides emotional connections, the next triggered aspects of soundscapes were "memory" and "life". Traditional and long-lasting soundscapes can positively influence residents' sense of place. The cultural value of a soundscape has a positive relationship with tourist loyalty, with place attachment as the mediator [57]. The cultural value of a soundscape plays a crucial role in shaping the local cultural identity, spreading the perceived image of the place, and fostering residents' local identity cognition. Taiyuan's peaceful and serene life soundscapes, complemented by the simple and practical architectural style of historical and cultural areas, resonate with residents' sentiments, making the place feel like home. Soundscapes not only evoke beautiful memories but also embody the residents' lives.

4.4. Comprehensive Discussion

Combining various methods, returning to the specific perception of soundscapes, traditional activity sounds and traditional commercial sounds symbolize traditional culture and are associated with residents' memories from their youth. Residents in Taiyuan's historical and cultural areas, through firsthand experiences of the historical changes in heavy machinery plant and mining machinery factories, closely link history with the lives of workers. Therefore, traditional activity sounds and similar soundscapes can positively predict residents' sense of place.

For many older residents, casual chats with neighbors and outdoor activities are essential aspects of life. Daily life sounds and recreational entertainment sounds convey positive emotions of happiness and satisfaction while embodying expectations and visions for a better life. The unchanging daily life provides residents with a sense of security and belonging. Thus, daily life sounds, leisure activity sounds, and entertainment activity sounds also positively predict residents' sense of place. Although natural sounds do not play a significant role in triggering residents' sense of place, the tranquility and beauty represented by natural soundscapes in the neighborhood environment had a significant positive relationship with residents' sense of place [58]. Residents' perception frequency of natural sounds positively predicts place attachment. On the contrary, in the comprehensive analysis, the physical environment with noise measurements exceeding standard limits is mainly concentrated in soundscapes such as commercial sounds, traffic sounds, and pet sounds. An increase in the perception frequency of these soundscapes may cause residents' aversion and even negatively predict their sense of place.

5. Conclusions

This study focused on four historical and cultural areas in Taiyuan City, and utilized on-site measurements, questionnaire surveys, statistical analysis, and qualitative analysis to investigate the influence of individual evaluations and soundscape perceptions on residents' sense of place in residential historical and cultural areas. Additionally, this study aims to explore the specific mechanisms through which soundscapes trigger residents' sense of place, yielding the following conclusions:

1. The soundwalk method revealed that among the 11 sound sources, traffic noise and commercial broadcast noise exceeded standard limits at certain measurement points. Simultaneously, residents' subjective preferences for traffic noise were the lowest, despite its highest perception frequency. In the "human–sound–place" system's perspective, the disadvantaged status of natural sounds and traditional sounds in the overall soundscape composition of historical districts should be elevated. It is necessary to conduct soundscape optimization design based on the research conclusions of soundscape preferences to enhance residents' evaluation of historical and cultural areas;

2. Regarding individual evaluations, residents exhibited an overall low level of historical understanding of their neighborhoods. Evaluations of the degree of neighborhood features and cultural preservation were also not high, failing to reach satisfactory levels. Structural equation model results indicated that both residential environment evaluations and neighborhood evaluations had a significant and positive impact on place attachment and place identity. In terms of place attachment, the influence of residential environment evaluations was greater than that of neighborhood evaluations. Conversely, neighborhood evaluations had a stronger impact on place identity compared to residential environment evaluations. To enhance residents' sense of place, it is necessary to strengthen public participation and community governance to promote the sustainable development of the community. The optimization methods of soundscapes should consider both the protection of the district soundscapes and the emotional and cultural needs of residents;
3. Residents' sense of place can be influenced by various types of soundscapes. Concerning soundscape elements, residents' subjective evaluations showed that the average preferences for various activity sounds and natural sounds were higher than their perception frequencies. The impact of soundscape preferences on the sense of place was evident: the preferences for special activity sounds (leisure activity sounds, entertainment activity sounds, traditional commercial sounds, and traditional activity sounds) were positively related to place attachment and place identity. The impact of soundscape perception frequencies on the sense of place was observed in the significantly positive relationship between the soundscape perception frequency with a moderate discrepancy between current and expected sounds (daily life sounds, birdsong and insect sounds, entertainment activity sounds, and natural phenomenon sounds) and place attachment. Conversely, the soundscape perception frequency with minimal discrepancy between current and expected sounds (commercial sounds, traditional commercial sounds, traffic sounds, and pet sounds) were negatively related to place attachment and place identity;
4. Complementing and cross-validating with quantitative data, the five main soundscapes have another perspective of influence on residents' sense of place from a qualitative angle. Traditional activity sounds such as festival activity sounds and traditional commercial sounds like street vendors' yells and craft-making sounds effectively enhanced residents' sense of place by triggering memories, embodying culture, and connecting emotions. Daily life sounds like residents chatting and children playing maintained residents' living conditions and created visions. The integration of local dialects triggered residents' sense of place from emotional and cultural perspectives. Leisure activity sounds such as singing, dancing, and fitness activities, as well as entertainment activity sounds like club activities and playing board games or chess, mainly triggered residents' sense of place from life and emotional connection perspectives;
5. The grounded theory research revealed that the sense of place emerged in residents from five dimensions: memory, emotion, life, culture, and vision. The most triggered aspect of soundscapes was emotion, followed by memory and life. The triggering mechanisms for the sense of place could be summarized into five paths: triggering memories; connecting emotions; linking life; embodying culture; and creating visions.

This research comprehensively analyzed the impact of soundscapes on residents' sense of place in residential historical and cultural areas using multiple methods. However, this study has some limitations. Firstly, the research results may be influenced by regional and cultural differences, so caution should be exercised when generalizing to other areas. Secondly, further research is needed to delve deeper into the social and cultural factors contributing to the formation of historical and cultural areas. Finally, changes in social, cultural, and economic environments can affect residents' sense of place, requiring more extended and in-depth observational studies of these factors. Further research will be needed to explore the sense of place in historical and cultural areas. In general,

more research can be conducted on different types of districts and historical heritage in future studies. In other types of historical districts with different functions, such as tourist areas, commercial and recreational areas, or parks, the main activities and purposes of the crowd are different. Therefore, the detailed relationship between soundscape evaluation and sense of place should also be verified in these contexts. The human–place relationship in historical and cultural areas needs to be expanded, and the human–place relationship research focusing on residents' environmentally friendly behaviors should also be paid attention to. Historical districts can also expand and refine the theory of sense of place through the exploration of soundscape cultural resources and community participation, enriching cultural geography's understanding of place theory, as well as exploring soundscape theory.

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Appendix A

Interview

- How do you feel about the overall physical environment in this area?
- How important is sound in your life?
- Can you still remember the sound environment in the residence and in the neighborhood?
- What was your experience in your previous residence? /If you had the opportunity to remove your home, would you want to?
- What has changed since you have moved in? /What are the reasons for wanting or not wanting to do so?
- What environmental conditions (including sounds) are the most difficult for you to part with?
- Can you still remember a residence in which the sound experience was especially important? If yes, what was/were the sound(s)? Why and how did this/they affect you?
- Are there sounds that you like very little or not at all?

Follow on question concerning development: Have you always felt this way about that/those sound(s)?

- Do you have hobbies or leisure time activities which expose you to a high level and/or extended periods of sound? If so, what are they and how long/high is your exposure to sound?
- What kind of sounds are you aware of in this environment?
- What is pleasant/unpleasant about these sounds?
- What kind of emotions do you experience when hearing these sounds?
- Are there sounds which you cannot identify?
- Are there sounds which stimulate or support you during certain activities and moods?
- Are there sounds which you appreciate to divert your attention from a given activity?

- What actions for improving sound conditions do you expect from:
  - your landlord;
  - your neighbors;
  - the municipal authorities;
  - the government.

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