LAF | https://doi.org/10.15302/J-LAF-2026-0017
Volume 14 / Issue 2 / 260017 / 2026

Received Date | 2025-07-31 Accepted Date | 2025-11-26

How Individual and Sound Characteristics Interactively Determine Perceived Soundscape Restorativeness in Coastal Urban Spaces —An Empirical Study in a Typical Sea-fronting Context

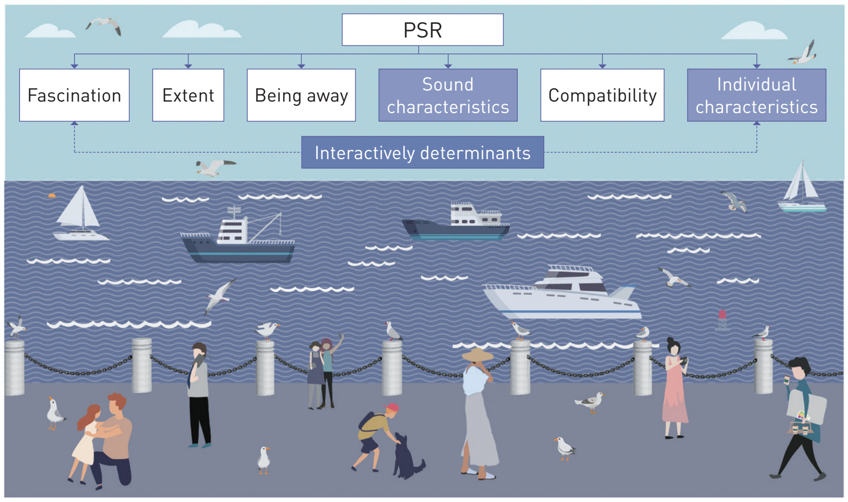
Xinxin REN[1,*], Yunhao LI[1], Hanmo LIU[1], Meudjeu TOGNIA[2]

1 School of Architecture & Fine Art, Dalian University of Technology, Dalian 116024, China
2 School of Chemical Engineering, Dalian University of Technology, Dalian 116024, China

*CORRESPONDING AUTHOR
Address: No.2 Linggong Road, Ganjingzi District, Dalian 116024, China
Email: renxinxin@dlut.edu.cn

GRAPHICAL ABSTRACT

This study explores coastal urban spaces as nature-based therapeutic landscapes and examines perceived soundscape restorativeness (PSR) with all four theoretical components of Fascination, Being away, Compatibility, and Extent on site. The characterization of PSR in coastal urban spaces is understood with reorganized components under individual and sound factors interactions.



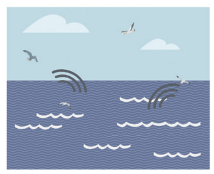
Practical guidance

Considering soundscape benefits for psychological restoration

Therapeutic landscape potential could be enhanced considering the characterization of PSR in coastal urban spaces

People-oriented design

In response to the needs of visitors with different sociodemographic characteristics and behavioural patterns, optimize the adaptability between landscape and soundscape design



Soundscape optimization

Prioritize the protection of natural soundscapes, focus on safeguarding highly restorative natural sounds such as sea waves and wind sounds, and reduce the interference from mechanical sounds and excessive anthropogenic sounds

ABSTRACT

The restorative soundscape is an important consideration in the health benefits of coastal environments. However, limited research has examined the perceived restorativeness of coastal soundscapes on site, considering both individual and sound characteristics. This study explores coastal urban spaces as nature-based therapeutic landscapes for public mental well-being and investigates how individual and sound factors interactively determine the perceived soundscape restorativeness (PSR) through theoretical components, using a field questionnaire survey in a typical sea-fronting context in China. The results indicate that the PSR varies depending on both individual and sound characteristics. Sociodemographic factors, behavioral patterns, dominant sounds, and holistic soundscape evaluations significantly influence the PSR. Individual characteristics including occupation, education level, visit duration, frequency, and activity intensity are associated with all four theoretical components: Fascination (F), Being away (A), Compatibility (C), and Extent (E). Moreover, individual factors play an even greater role than sound characteristics in determining F, A, and C components. By integrating theoretical components with individual and sound characteristics, a robust framework was established using an extended Perceived Restorativeness Soundscape Scale (PRSS) to explain restorative soundscape in coastal urban spaces. Sound and individual factors, beyond theoretical components, account for nearly three quarters of the total variance (73.45%). This study highlights the interplay between restorative components, sound environment, sociodemographic factors, and visit behaviors in determining the PSR. The findings provide empirical insights for optimizing soundscapes in coastal environments to enhance their therapeutic landscape potential and landscape design benefits.

KEYWORDS

Coastal Urban Space; Sociodemographic Characteristics; Behavioral Pattern; Perceived Soundscape Restorativeness; Soundscape Evaluation; Therapeutic Landscape

HIGHLIGHTS

- The PSR is examined in coastal urban spaces considering visitor and visit characteristics
- Individual factors are associated with more PSR components than sound factors themselves
- Individual factors could be more important than sound factors in determining PSR
- Theoretical components of PSR are reorganized under multidimensional factors interactions

RESEARCH FUNDS

- Humanities and Social Sciences Project, the Ministry of Education of China (No. 23YJCZH176)
- Economic and Social Development Project, Liaoning Province of China (No. 2023lslybkt-029)

1 Introduction

Analogous to “green spaces” in discussions of environmental health and therapeutic landscapes, blue spaces were described as “health-enabling places and spaces, where water is at the center of a range of environments with identifiable potential for promoting human well-being”[1]. Recent studies have increasingly highlighted the therapeutic benefits of blue spaces, demonstrating a positive correlation between coastal proximity and indicators of general health, mental well-being, and physical activity[2–4]. Moreover, experimental research on natural and built environments consistently identifies coastal urban spaces as among the most preferred locations for relaxation[5], which additionally are highly valued by local residents for enhancing both individual and family well-being[6].

While various theories help explain the relationship between coastal urban spaces, health, and well-being, the Attention Restoration Theory (ART)[7] provides a particularly effective framework for understanding this connection. The ART posits that natural environments can alleviate urban stress and facilitate recovery from mental fatigue caused by information overload, environmental stressors, and high ambient noise levels in urban settings[7–9]. Empirical evidence suggests that, among different natural environments, coastal visits are associated with the highest levels of psychological restoration[10]. Beyond visual aesthetics, the soundscape plays a significant role in sensory perception at the coast[11]. The term “soundscape” refers to the aural environment as it is perceived, experienced, and interpreted by individuals in a given context[12]. Unlike traditional perspectives that frame environmental sounds primarily in terms of noise pollution (e.g., traffic noise), soundscapes are increasingly recognized as valuable environmental resources that contribute to well-being. Perceived soundscape restorativeness (PSR) has emerged as an important area of study[13], highlighting the role of sound environments in promoting mental health.

Based on the four theoretical components that characterize a restorative environment as outlined in ART—Fascination, Being-away (including Being-away-to and Being-away-from), Compatibility, and Extent (including Coherence and Scope)—the Perceived Restorativeness Soundscape Scale (PRSS) was developed to assess psychological restoration within a soundscape context[14]. According to PRSS evaluations based on these theoretical components, the dominance of natural sounds has been found to have stronger restorative effects[15–16]. PSR is associated with a “high-quality” sound environment, a concept that has been explored through various soundscape descriptors to understand which overall soundscape evaluations may have restorative effects. In addition to soundscape research, sound characteristics have increasingly been recognized as crucial elements that can affect the therapeutic potential of various environments[17–18]. A recent study conducted in coastal environments found that both perceived holistic soundscapes and sound types influence restorativeness across emotional, physiological, cognitive, and behavioral dimensions[19]. However, restorative environments differ in the levels of each component[14], which in turn affects the overall PSR of the environment. The influence of sound characteristics on each PRSS component in coastal environments remains underexplored.

The therapeutic significance and multidimensional experiences associated with coastal urban spaces underscore the need to enhance or promote their restorative capacity. However, this goal is often contested by different visitor groups with varying interests. Moreover, focusing on well-being presents challenges in explaining and measuring the perception of subjective experiences, which may differ significantly among individuals[20–21]. Although recent research has systematically examined the effects of sociodemographic characteristics on the PSR in urban green spaces[22–24], there has been limited consideration of how sociodemographic and behavioral characteristics interact and influence the PSR in coastal urban spaces.

Therefore, this study emphasizes that the PSR of an environment is influenced by individuals' perceptions of the PRSS components, and empirically investigates the PSR in coastal urban spaces through an *in situ* survey conducted in a coastal environment, addressing two primary research questions: 1) Are there differences in PSR with respect to the theoretical components among individuals and sound characteristics? And 2) how do sociodemographic characteristics, behavioral patterns, dominant sounds, and holistic soundscape evaluations influence the PSR of coastal urban spaces across theoretical components?

2 Methodology

2.1 Study Area

Dalian, a livable city situated along China's northern coastline, has been renowned for its coast. A sea-fronting area in the city was selected as the study area, which is typical of coastal urban spaces found in China and other Asian countries, encompassing a central square and its surrounding recreational open spaces. The environmental advantages of coastal landscapes have made it a highly popular destination for recreation. The study area has complex soundscape, incorporating natural, anthropogenic, and mechanical sounds[25].

Regarding the environmental advantages of landscapes in the coastal zone[26], the study area also has the best climate conditions compared to other coastal areas in the city. Furthermore, surrounded by open spaces, mountains and water bodies, it has become a highly popular destination for recreation.

2.2 Questionnaire Design

Based on the research questions, the field questionnaire was structured into five sections: sociodemographic information, behavioral patterns (i.e., visit purpose, frequency, activity intensity, and duration), identification of dominant sounds, holistic soundscape evaluation, and PRSS responses.

The standard for soundscapes by International Organization for Standardization has emphasized that evaluating a sound environment requires the identification of individual sounds, where the identification of subjectively dominant sounds plays a crucial role in improving a given soundscape[27]. Therefore, the section of identification of dominant sounds was structured to address two key aspects: the types of sounds that can be heard and the perceived dominance of these sounds[28]. Each respondent was asked to report the three most prominent sound sources they perceived in the coastal environment in the dominance order.

The section of holistic soundscape evaluation included questions on sound appropriateness, subjective loudness, and acoustic comfort, using a five-point scale[29–30] with 1 represents highly negative response and 5 represents highly positive response①. The inclusion of these soundscape descriptors as indicators for holistic soundscape evaluation was based on two primary reasons: 1) sound appropriateness, subjective loudness, and acoustic comfort provide more objective and accurate measures of perceptual attributes compared with other sound affective quality indicators, and 2) these descriptors are more comprehensible to a broader range of interviewees, regardless of their occupation or educational background, allowing for more effective and reliable responses.

The last section was designed to assess residents' PSR by measuring all "FACE" components: Fascination (F), Being-away-to (A1), Being-away-from (A2), Compatibility (C), Coherence (E1), and Scope (E2)[31]. Corresponding to each item, the participants were asked, "How do you experience and agree with the statement?" Their PSR experiences were reported with a five-point scale: 1 means "not at all" and 5 means "completely."

2.3 Data Collection

Face-to-face interviews were conducted to gain in-depth insights into participants' real understanding and perceptions of the sound environment. The field survey was carried out by a research team under supervision between 14:00 and 17:00, when intensified crowd activity level was observed in the study area throughout daytime[32], during May and June—a period when outdoor activities

① To maintain consistency in scoring, responses to negatively framed items were adjusted so that higher PRSS scores consistently indicated a more positive restorative experience before data analysis.

are popular due to the favorable climate in Northeast China. Random sampling was employed on both weekdays and weekends to minimize biases arising from daily variations in visitation patterns.

Prior to the questionnaire survey, interviewers conducted a series of soundwalks to identify and select four survey zones with representative landscape features (i.e., memorial space, recreational space, sidewalk, and playground) and dominant sounds (Fig. 1). At each selected site, ambient sound levels were measured and recorded five times using BSWA801 sound level meter at the height of 1.5 m. Each measuring time lasted 1 min, with every 10 s recorded once[33]. The average measured A-weighted SPLs at the corresponding locations was calculated in Table 1. Then, a brief introduction was provided to randomly invited participants at each location, during which the study's purpose was explained, and the participants' habitual residence was verified[34], in order to ensure that only local residents (excluding tourists) were included in the formal questionnaire survey. Since an appropriate L_{Aeq} (the average level of environmental noise) threshold was required for soundscape quality evaluation, questionnaires collected at locations where ambient sound levels exceeded the threshold (73 dBA) were excluded from the database[28]. A total of 230 questionnaires were distributed, of which 201 were valid, yielding an effective response rate of 87%.

Table 1: Average ambient sound level measurements in the study area

	L_{Apeak}	L_{Amax}	L_{Amin}	L_{Aeq}
Zone A—memorial space	91.02	74.71	54.19	60.83
Zone B—recreational space	89.88	74.09	53.54	61.78
Zone C—sidewalk	91.31	77.62	58.24	65.62
Zone D—playground	93.43	80.89	61.84	69.14

NOTES

L_{Apeak} means the maximum instantaneous A-weighted sound pressure level; L_{Amax} means the highest A-weighted sound pressure level; and L_{Amin} means the minimum A-weighted sound pressure level.

Figure 2 shows the demographic information of the participants. They were approximately balanced across different occupations, with administrative staff representing the largest group (27%). Most participants have received senior middle school education, while as many as 25% of the participants had at least college education. In terms of gender ratio, the male (60%) was higher than the female (40%). These distributions of the samplings were consistent with the report of typical urban residents' outdoor activities during the survey seasons in China[35]. Corresponding to the valid questionnaires, the average measured L_{Aeq} at the surveyed

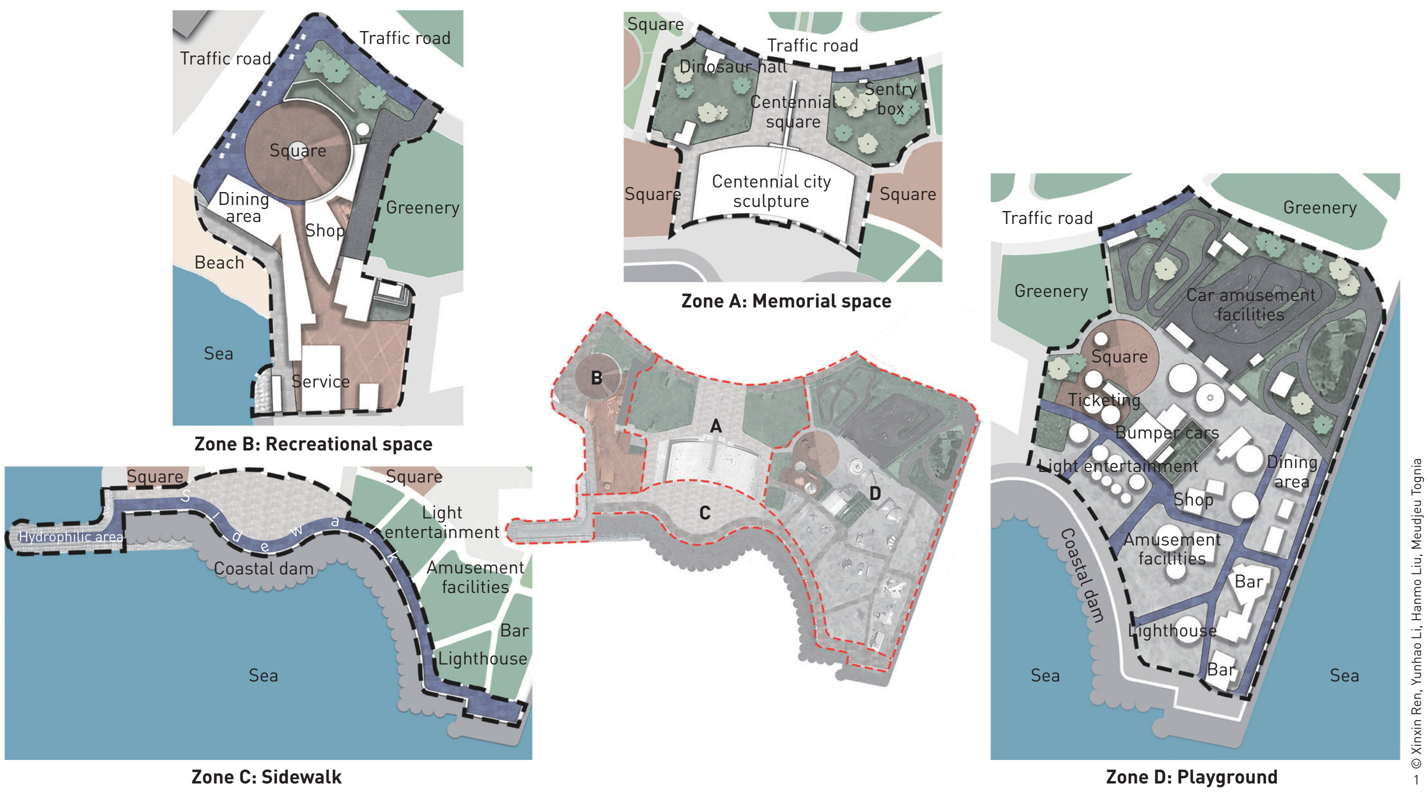


Fig. 1 The environmental features of the study area.

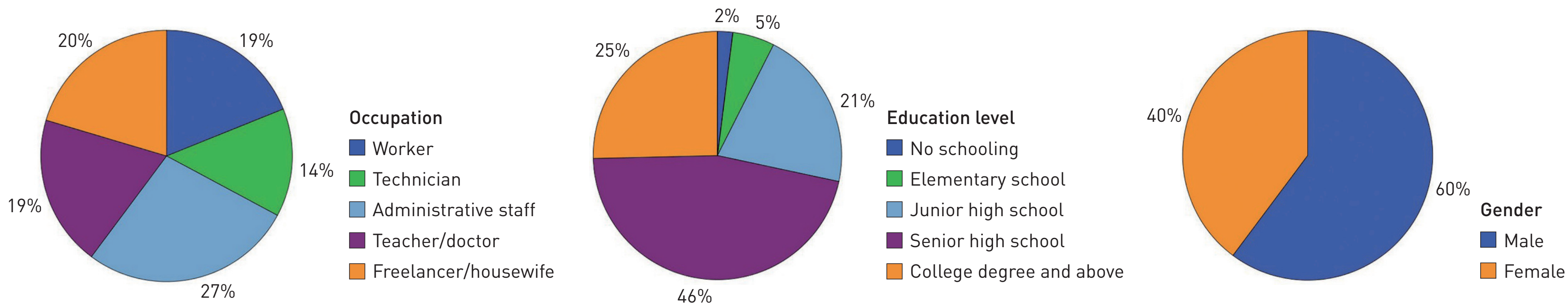


Fig. 2 Basic statistics of the sampling composition at the individual level.

locations ranged from 60.83 to 69.14 dBA. This range represents typical L_{Aeq} values for assessing soundscape quality in urban open spaces.

The reliability of the samples was assessed using mean PRSS scores for each restorative component (Table 2). The Cronbach's alpha values ranged from 0.716 to 0.906, indicating strong internal consistency. Additionally, the Kaiser-Meyer-Olkin (*KMO*) measure of sampling adequacy ranged from 0.6 to 0.8, with Bartlett's test of sphericity yielding significant results ($p < 0.01$), confirming the validity of the database. These results indicated that the collected data were sufficiently reliable for further analysis[36–37].

2.4 Data Analyses

The data analyses aimed to examine in detail the influence of

Table 2: Reliability and validity of the questionnaire database for theoretical components of PSR

Questions for each component		Cronbach's alpha	*KMO*	*Sig.*
Fascination	I find this sonic environment appealing (AP). My attention is drawn to many of the interesting sounds here (AT). These sounds make me want to linger here (LG). These sounds make me wonder about things (WD). I am engrossed by this sonic environment (EG).	0.906	0.8	$p < 0.01$
Being-away-to	I hear these sounds when I am doing something different to what I usually do (DT). This is a different sonic environment to what I usually hear (DS). I am hearing sounds that I usually hear (UH).	0.850	0.7	$p < 0.01$
Being-away-from	This sonic environment is a refuge from unwanted distractions (DA). When I hear these sounds I feel free from work, routine, and responsibilities (FR). Listening to these sounds gives me a break from my day-to-day listening experience (BR).			
Compatibility	These sounds relate to activities I like to do (AC). I rapidly get used to hearing this type of sonic environment (UT). Hearing these sounds hinders what I would want to do in this place (HI).	0.716	0.6	$p < 0.01$
Coherence	All the sounds I'm hearing belong here (BL). All the sounds merge to form a coherent sonic environment (CH). The sounds I am hearing seem to fit together quite naturally with this place (TG).	0.846	0.7	$p < 0.01$
Scope	The sonic environment suggests the size of this place is limitless (LL).			

individual factors (demographics and behavioral patterns) and sound-related factors (dominant sounds and holistic soundscape evaluations) on the PSR. First, the normality of each component was assessed using histograms, normality plots, and probability–probability (P–P) plots. The asymptotic normality of these variables were also verified based on descriptive statistics analysis of skewness ($-1.007 \le S \le 0.207$) and kurtosis ($-1.342 \le K \le 0.957$)[28], with absolute values lower than 10 and 3, respectively.

Second, to determine whether specific individual and sound characteristics influenced different restorative components, one-way analysis of variance (ANOVA) followed by post hoc tests was mainly conducted.

Third, to further explore the significance of various factors, categorical regression analysis (CATREG) was applied, offering a comprehensive evaluation of the most influential variables. The CATREG model has greater applicability and flexibility in handling complex datasets containing categorical variables and enables the measurement of the relative importance of explanatory variables which were connected with various individual and sound characteristics[38].

Finally, principal component analysis (PCA) was conducted to examine PRSS item evaluations in conjunction with individual and sound-related variables. This approach allowed for an in-depth discussion on the characterization of the soundscape restoration potential of coastal blue spaces, extending the traditional PRSS framework.

3 Results

3.1 PSR Considering Sociodemographic Factors

The influence of sociodemographic characteristics (independent variables) on restorative scores (dependent variables) was analyzed using one-way ANOVA, followed by LSD/Duncan post hoc tests for occupation and education level, and independent-sample t-tests for gender. The null hypothesis stated that there were no significant differences in mean scores across occupations, education levels, and gender. As shown in Table 3, the analysis of one-way ANOVA led to the rejection of the null hypothesis for both occupation and education level ($p < 0.05$).

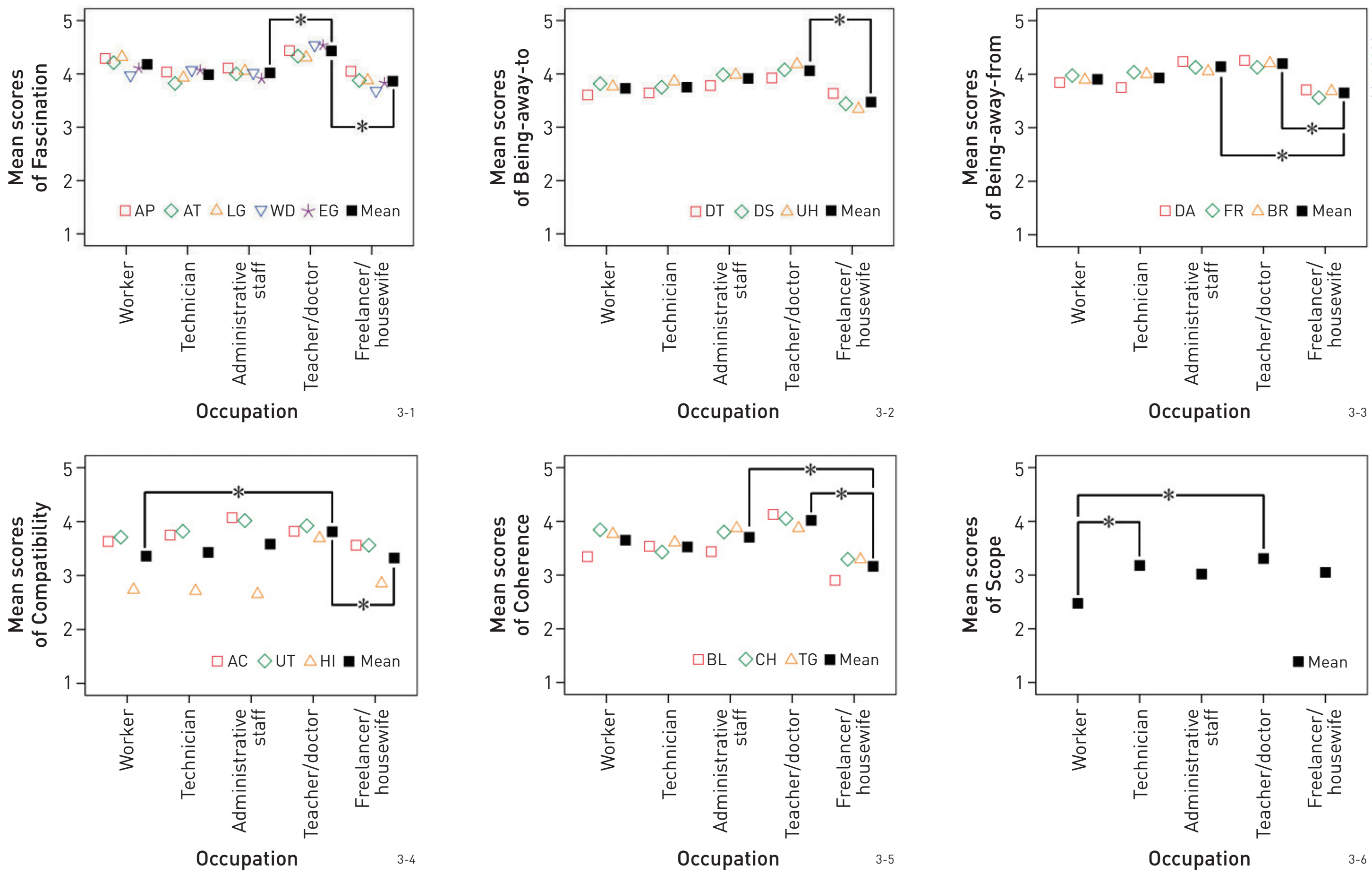
As illustrated in Fig. 3, while higher mean scores were observed for Fascination, Being-away-to, and Being-away-from, ranging from 3.79 to 4.09 (approximately "very much"), compared with Compatibility, Coherence, and Scope, ranging from 3.00 to 3.61 (above "somewhat"), significant differences in PSR emerged between various occupational groups. Specifically, administrative staff reported significantly lower F-scores than teachers/doctors (4.11 ± 0.42 vs. 4.44 ± 0.28). Similarly, freelancers/housewives had significantly lower scores for Being-away-from and Coherence compared with administrative staff. Additionally, teachers/doctors exhibited significantly higher PSR scores across Fascination, Being-away-to, Being-away-from, Compatibility, and Coherence than freelancers/housewives (4.15 ± 0.32 vs. 3.49 ± 0.40). A notable disparity was also found between workers and teachers/doctors for Scope (2.47 ± 0.67 vs. 3.31 ± 0.74). Across all components, teachers/doctors consistently reported the highest PSR scores, whereas workers and freelancers/housewives tended to report lower scores.

Figure 4 highlights the significant differences in PSR across education levels, particularly between individuals with an elementary school education and those with a college degree or higher (3.31 ± 0.28 vs. 4.03 ± 0.30) for Fascination, Being-away-from, and Compatibility. Additionally, individuals with only an elementary school education exhibited significantly lower scores in Fascination and Being-away-from compared with those with junior and senior middle school education. These findings suggest that individuals with lower education levels tend to experience lower PSR than those with higher education levels. To examine whether restoration scores followed a specific trend upon education level, curve estimation analyses were conducted separately for each component. Linear regression models ($0.78 \le R^2 \le 0.87$, $p < 0.05$)

Table 3: Significance levels of the differences in PSR components among sociodemographic factors

Sociodemographic factor	Fascination	Being-away-to	Being-away-from	Compatibility	Coherence	Scope
Occupation	0.007*	0.020*	0.001*	0.021*	0.000*	0.102
Education level	0.002*	0.026*	0.000*	0.150	0.146	0.827

NOTE
* means $p < 0.05$.



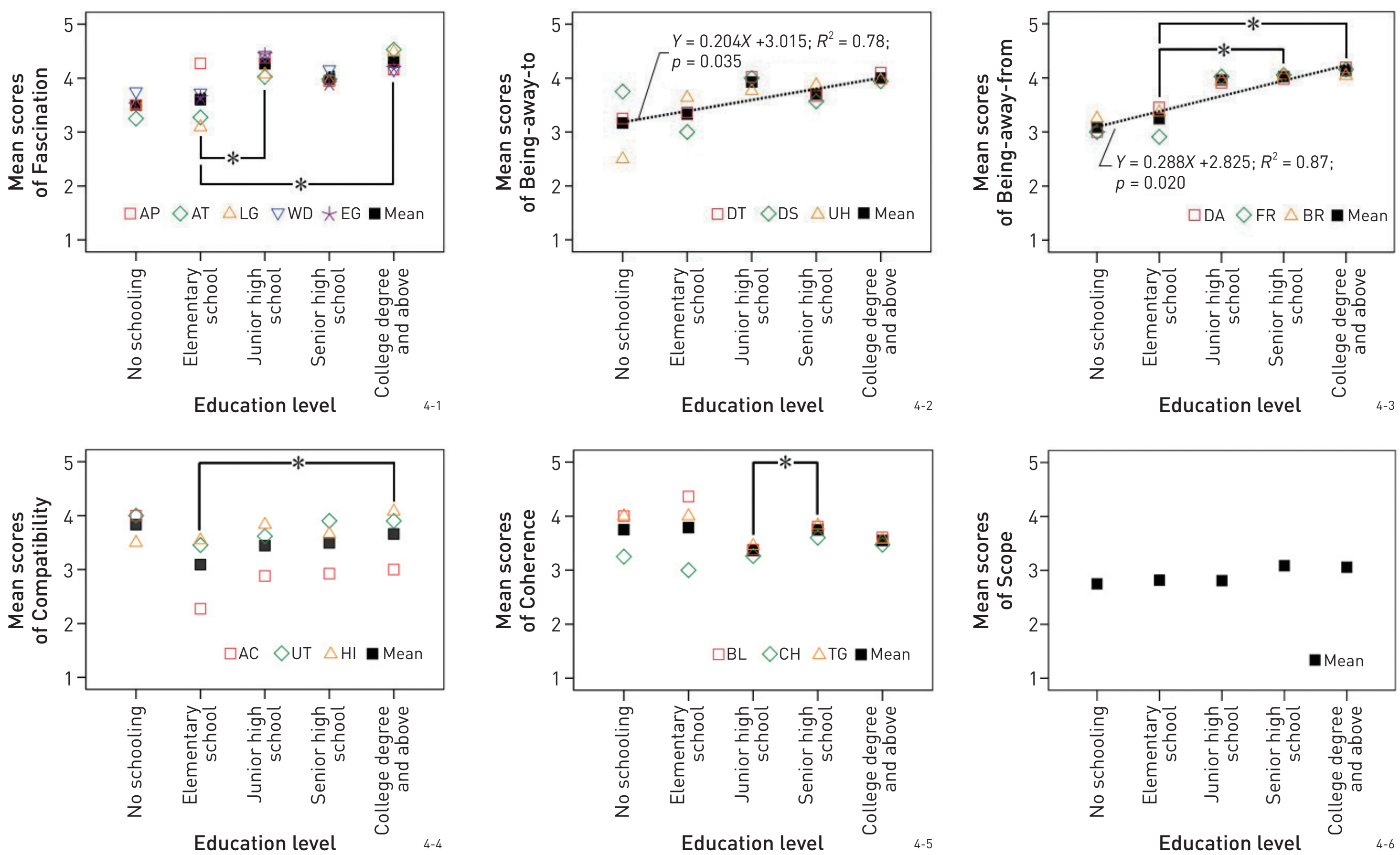


Fig. 3 Average PSR scores for each component influenced by occupation, with post hoc comparison of restorative scores (* means $p < 0.05$).

Fig. 4 Average PSR scores for each component influenced by education level, with post hoc comparison of restoration scores (* means $p < 0.05$). Linear trend curves and coefficients of determination R^2 ($p < 0.05$) included.

demonstrated a strong positive relationship between education level and restoration scores for Being-away-to and Being-away-from (Figs. 4-2, 4-3). These results indicate that individuals with higher education levels are more likely to perceive greater psychological restoration, particularly in terms of being-away experiences.

3.2 PSR Considering Behavioural Factors

As shown in Table 4, the analysis of one-way ANOVA led to the rejection of the null hypothesis for different behavioural patterns ($p < 0.05$). The results of the mean differences in restoration scores suggest that behavioral patterns significantly influence PSR.

The comparisons in PSR and the identification of specific significant differences based on visit duration, purpose, frequency, and activity intensity were presented as Table 5. Regarding visit duration, significantly higher restoration scores were observed when the visit lasted at least one hour. Notably, significant differences emerged between visits lasting 30 ~ 60 min and those lasting 1 ~ 3 h (3.40 ± 0.40 vs. 3.98 ± 0.35) for Fascination, Being-away-to, Being-away-from, and Compatibility, suggesting that longer visits contribute to enhanced psychological restoration. In terms of visit purpose, participants who engaged in fitness-related activities reported significantly lower scores than those whose motivations were related to mental relaxation, sightseeing, or social gatherings (3.45 ± 0.37 vs. 3.81 ± 0.40) for Being-away-from, Compatibility, and Coherence. Interestingly, high-intensity activities sometimes led to significantly higher scores compared with lower-intensity activities. Specifically, significant differences were observed between high- and relatively high-intensity activities for Fascination and Compatibility, as well as between high- and relatively low-intensity activities for Being-away-from. Additionally, as expected, the lowest-intensity activities resulted in significantly higher scores. For instance, restoration scores for Fascination, Compatibility, and Coherence were significantly higher in low-intensity activities compared with relatively high-intensity activities (3.95 ± 0.36 vs. 3.52 ± 0.39), while for Being-away-to, significantly higher scores were found in low-intensity compared with relatively low-intensity activities (3.93 ± 0.30 vs. 3.07 ± 0.47). Regarding visit frequency, notable differences were identified when the highest visit frequency (almost every week) was considered. Individuals who visited nearly every week reported significantly lower scores compared with those who visited every month or so, every two to six months, seldom, or for the first time (2.85 ± 0.25 vs. 3.60 ± 0.48) for Fascination, Compatibility, Coherence, and Scope. These scores corresponded to evaluations ranging from “somewhat” to “very much,” suggesting that less frequent visits may enhance the perception of psychological restoration in coastal environments.

To examine potential trends between behavioral variables and restoration scores, curve estimation analyses were conducted for each component. Regarding visit duration, a positive linear relationship was observed for Fascination ($Y_{\text{Fascination}} = 0.151X_{\text{Duration}} + 3.582$, $p = 0.006$) and Compatibility ($Y_{\text{Compatibility}} = 0.118X_{\text{Duration}} + 3.112$, $p = 0.035$). In contrast, negative linear relationships were identified between activity intensity and restoration scores for Compatibility ($Y_{\text{Compatibility}} = -0.108X_{\text{Activity}} + 3.827$, $p = 0.003$), Coherence ($Y_{\text{Coherence}} = -0.103X_{\text{Activity}} + 3.921$, $p = 0.012$), and Scope ($Y_{\text{Scope}} = -0.166X_{\text{Activity}} + 3.484$, $p = 0.016$). Additionally, a positive linear relationship was found between visit frequency and coherence ($Y_{\text{Coherence}} = 0.113X_{\text{Frequency}} + 3.272$, $p = 0.043$). These findings indicate that as visit duration increases and both visit frequency and physical activity intensity decrease, the perceived restorative potential of the Fascination, Compatibility, Coherence, and Scope tends to improve.

3.3 PSR Considering Dominant Sound Sources

Before analyzing the influence of dominant sounds on PSR, the predominant sound sources at the coast were identified and

Table 4: Significance levels of the differences in PSR components among behavioural factors

Behavioural factor	Fascination	Being-away-to	Being-away-from	Compatibility	Coherence	Scope
Duration	0.000*	0.000*	0.002*	0.021*	0.397	0.886
Purpose	0.304	0.380	0.170	0.242	0.128	0.149
Frequency	0.000*	0.000*	0.032*	0.052	0.014*	0.003*
Activity intensity	0.054	0.019*	0.002*	0.000*	0.026*	0.049*

NOTE
* means $p < 0.05$.

Table 5: Influence of visit duration, purpose, frequency, and activity intensity on PSR components, with post hoc comparison of restorative scores

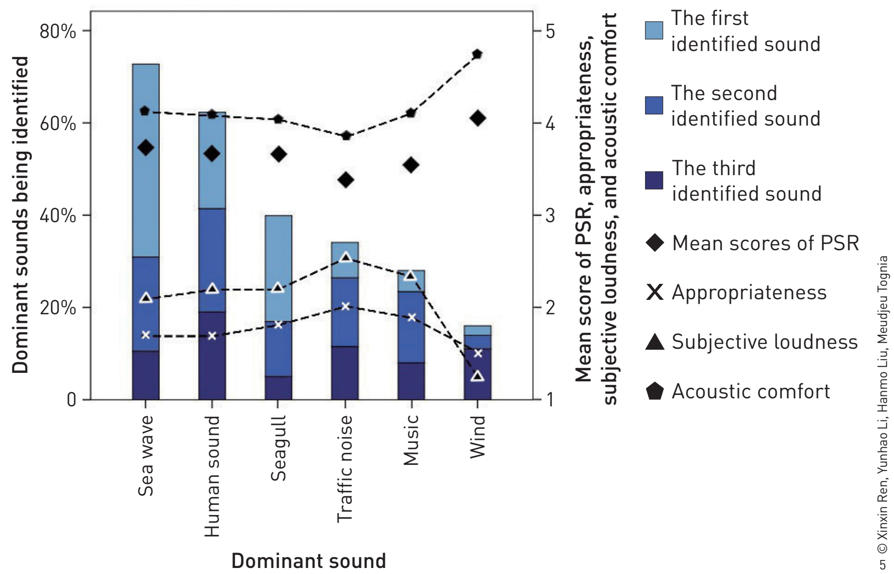
Dependent variable	Independent variables				
	Mean difference	D1/P1/I1/F1	D2/P2/I2/F2	D3/P3/I3/F3	D4/P4/I4/F4
Fascination	D2/P2/A2/F2	0.91/−0.02/0.23/−0.72	—	—	—
	D3/P3/A3/F3	0.21/0.02/0.09/−0.81*	−0.70*/0.04/−0.14/−0.09	—	—
	D4/P4/A4/F4	0.10/0.27/0.26*/−0.43	−0.81*/0.30/0.03/0.29	−0.11/0.25/0.17/0.38	
	D5/P5/A5/F5	0.42/0.23/−0.23/−0.36	−0.50/0.25/−0.46/0.36	0.20/0.21/−0.32/0.45*	0.31/−0.05/−0.49*/0.06
Being-away-to	D2/P2/A2/F2	0.02/−0.28/0.86/−0.82	—	—	—
	D3/P3/A3/F3	−0.68*/−0.10/0.01/−0.88	−0.70*/0.19/−0.85/−0.06	—	—
	D4/P4/A4/F4	−0.56*/−0.08/0.27/−0.50	−0.58*/0.20/−0.59/0.32	0.12/0.02/0.26/0.38	—
	D5/P5/A5/F5	−0.20/0.21/−0.01/−0.28	−0.22/0.49/−0.87/0.54	0.48/0.31/−0.02/0.60	0.35/0.29/−0.28/0.22
Being-away-from	D2/P2/A2/F2	0.45/−0.20/0.86*/−0.18	—	—	—
	D3/P3/A3/F3	0.05/0.07/0.22/−0.15	−0.40*/0.26/−0.64/0.03	—	—
	D4/P4/A4/F4	−0.01/0.06/0.12/−0.19	−0.47*/0.26/−0.75/−0.00	−0.07/0.00/−0.10/−0.03	—
	D5/P5/A5/F5	0.42/0.31/−0.10/0.33	−0.04/0.50*/−0.96*/0.52	0.36/0.24/−0.32/0.49	0.43/0.24/−0.21/0.52/
Compatibility	D2/P2/A2/F2	−0.15/0.02/0.32/−0.63*	—	—	—
	D3/P3/A3/F3	−0.61/−0.02/0.17/−0.65*	−0.46*/−0.04/−0.16/−0.02	—	—
	D4/P4/A4/F4	−0.60/0.13/0.58*/−0.45	−0.45*/0.11/0.25/0.18	0.01/0.15/0.41/0.20	—
	D5/P5/A5/F5	−0.51/0.36*/0.04/−0.52	−0.36/0.34/−0.28/0.11	0.10/0.38*/−0.13/0.13	0.09/0.23/−0.54*/−0.07
Coherence	D2/P2/A2/F2	−0.06/0.24/0.37/−0.75*	—	—	—
	D3/P3/A3/F3	−0.13/−0.05/0.36/−0.55*	−0.07/−0.29/−0.01/0.20	—	—
	D4/P4/A4/F4	−0.18/0.27/0.46*/−0.86*	−0.13/0.03/0.09/−0.10	−0.06/0.32/0.10/−0.31	
	D5/P5/A5/F5	−0.48/0.37/0.19/−0.77*	−0.43/0.13/−0.18/−0.02	−0.36/0.42*/−0.17/−0.22	−0.30/0.10/−0.27/0.08
Scope	D2/P2/A2/F2	0.67/1.04*/1.09/−1.25*	—	—	—
	D3/P3/A3/F3	0.72/0.40/0.45/−0.64	0.05/−0.65/−0.64/0.61	—	—
	D4/P4/A4/F4	0.59/0.40/0.63/−1.37*	−0.07/−0.64/−0.46/−0.12	−0.13/0.00/0.18/−0.73*	—
	D5/P5/A5/F5	0.80/0.40/0.60/−1.11*	0.13/−0.64/−0.49/0.15	0.08/0.01/0.15/−0.47	−0.20/0.00/−0.02/0.27

NOTES

1. * means $p < 0.05$.
2. Duration: D1 refers to 15 min or so; D2 refers to 30 min to 1 h; D3 refers to 1 ~ 2 h; D4 refers to 2 ~ 3 h; and D5 refers to up to 3 h.
3. Purpose: P1 refers to soothing mind and soul; P2 refers to sightseeing; P3 refers to going for party; P4 refers to leisure and entertainment; and P5 refers to fitness exercises.
4. Activity intensity: A1 refers to low intensity (e.g., take a rest, fishing); A2 refers to relative low intensity (e.g., chatting, communication); A3 refers to medium intensity (e.g., dating, enjoying the view); A4 refers to relative high intensity (e.g., walking, playing with children); and A5 refers to high intensity (e.g., square dance, play games, physical exercise).
5. Frequency: F1 refers to almost every week; F2 refers to every month or so; F3 refers to every two to six months; F4 refers to seldom; and F5 refers to the first time.

quantified. Figure 5 presents six dominant sounds perceived within the study area: natural sounds (sea waves, seagulls, and wind), anthropogenic sounds (human-related sound and music), and mechanical sounds (traffic noise). Among these, sea waves were the most frequently identified dominant sound, accounting for 73% of the total identification. When sea waves were perceived as the first dominant sound, the average restoration score was 3.81—approaching the "very much" level on the PRSS—aligning with expectations regarding the positive effect of natural sounds. This predominance suggested that the coastal sound environment offers a perceptual shift away from artificial, everyday noise. Interestingly, when wind was identified as the first dominant sound, the highest restoration score of 4.05 was recorded, exceeding the "very much" threshold for PSR, though wind was the least frequently identified dominant sound (16%). This heightened PSR may be linked to acoustic comfort, as wind-dominated environments were rated highest in terms of comfort (with an average score of 4.75, corresponding to "very comfortable"). Conversely, lower restoration scores were associated with anthropogenic and mechanical sounds. When human-related or music sounds were perceived as the first dominant sounds, the average score was 3.60, while mechanical sounds (traffic noise) resulted in the lowest average score of 3.38.

One-way ANOVA and post hoc tests confirmed that dominant sound types had significant effects on PSR components ($p < 0.05$) (Fig. 6). Notably, the restoration scores for traffic noise were significantly lower than those for natural sounds when sea waves or wind dominated the soundscape (3.38 ± 0.38 vs. 4.17 ± 0.32)



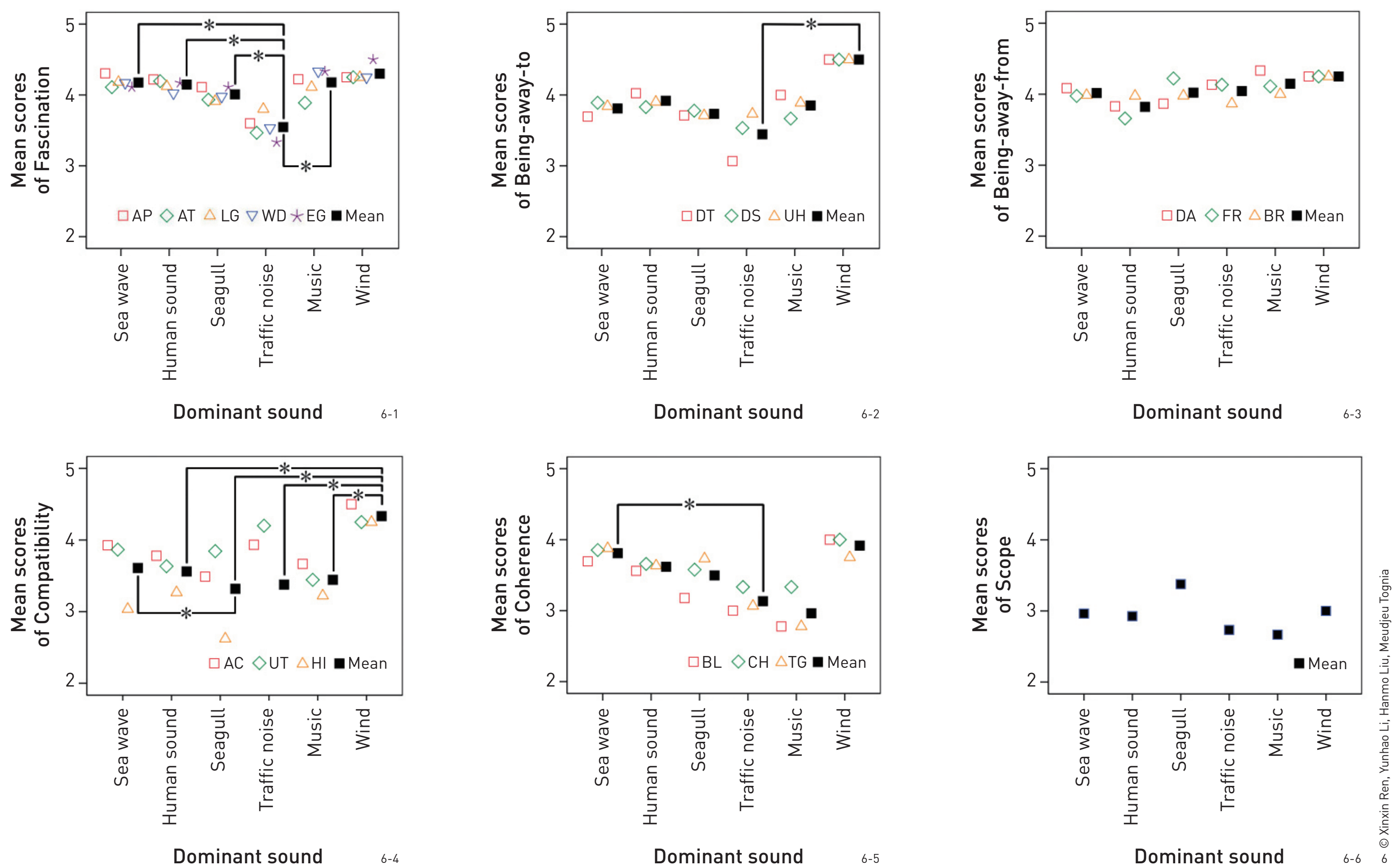


Fig. 5 Identification of the first dominant sounds and corresponding mean scores for PSR components.

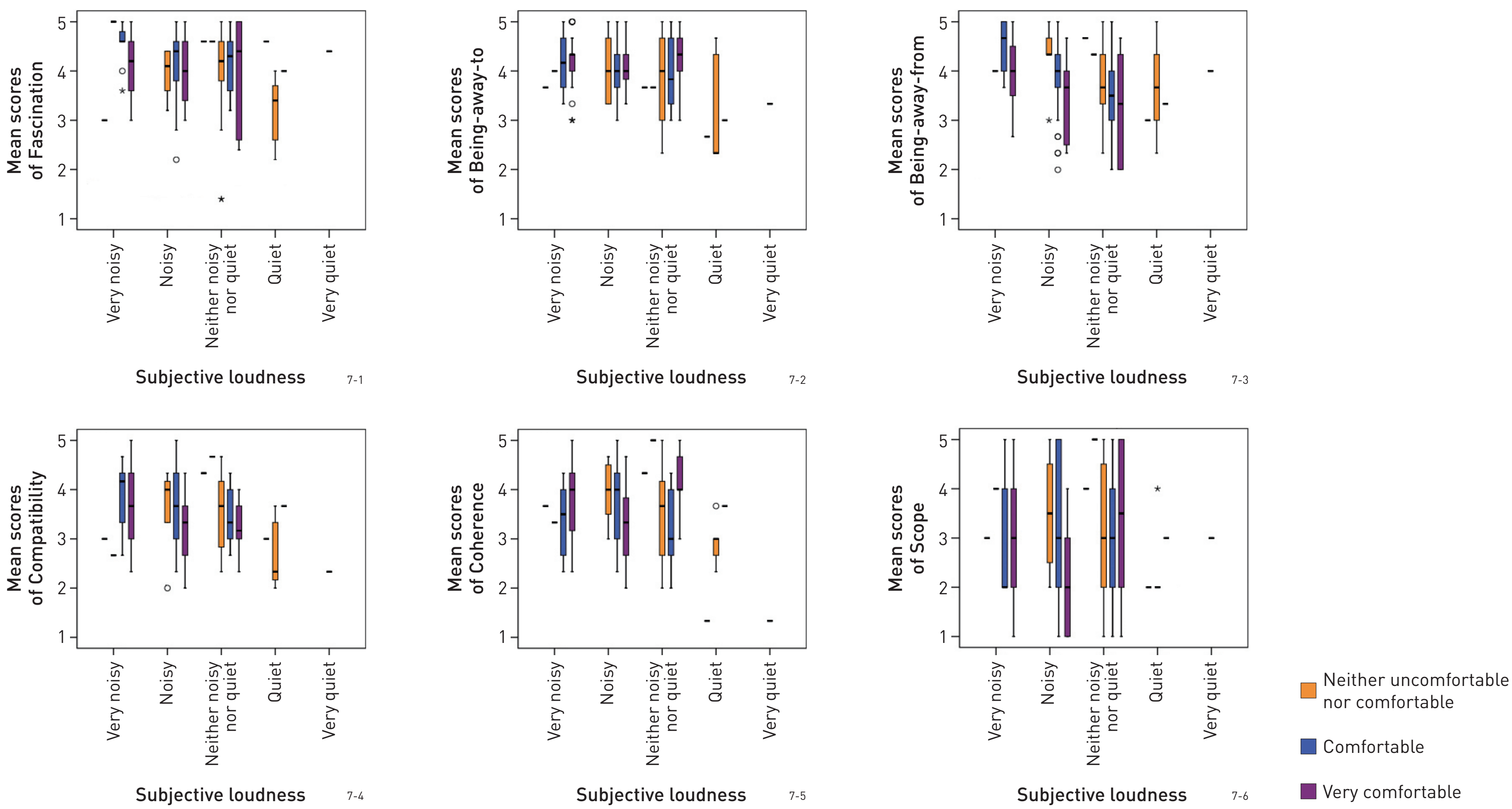
Fig. 6 Average PSR scores for each component influenced by dominant sounds, with post hoc comparison of restoration scores (*means $p < 0.05$).

and were also lower than those for anthropogenic sounds such as human speech and music for Fascination (3.55 ± 0.57 vs. 4.16 ± 0.31). Additionally, human-related and music sounds resulted in significantly lower scores than wind-dominated soundscapes for Compatibility (3.50 ± 0.34 vs. 4.33 ± 0.24). Among natural sounds, sea waves and wind were the most effective in promoting PSR, as their restoration scores were significantly higher than those of seagulls for Compatibility (3.97 ± 0.30 vs. 3.32 ± 0.38). These findings reinforced the restorative potential of natural coastal soundscapes, particularly when dominated by sea waves and wind, while highlighting the comparatively lower restorative effects of anthropogenic and mechanical sounds.

3.4 PSR Considering Holistic Soundscape Evaluations With Interactively Determinants

Appropriateness, subjective loudness, and acoustic comfort were evaluated to characterize the overall coastal sound environment. Interestingly, negative relationships between holistic soundscape evaluations and PSR scores were presented in Fig. 5, suggesting that higher PSR was associated with lower subjective ratings. Note that PSR scores were higher when sea waves and wind were the predominant sounds, despite lower levels of appropriateness and subjective loudness. Figure 7 presents the estimated mean scores for each component as influenced by holistic soundscape evaluations, with PSR reflected in the median scores of the box plots. The distribution of holistic soundscape evaluations revealed that the coastal sound environment was generally perceived as ranging from "neither noisy nor quiet" to "very noisy" in terms of subjective loudness, while acoustic comfort ranged from "neither uncomfortable nor comfortable" to "very comfortable." This suggested that local residents may have become accustomed to the relatively noisy coastal environment while still perceiving it as acoustically comfortable[30]. Additionally, median PSR scores were observed to increase as acoustic comfort ratings decreased for Being-away-to (Fig. 7-2), Being-away-from (Fig. 7-3), and Compatibility (Fig. 7-4). These findings could highlight the complex

Fig. 7 Holistic soundscape evaluation determinants influencing PSR components. Box plots represent extremum and quantile of restoration scores at varying subjective loudness level influenced by acoustic comfort levels, and the horizontal black bold line represents the median.



interplay between individuals and sound characteristics with PSR in coastal environments.

To examine the effects of appropriateness, subjective loudness, and acoustic comfort on PSR, a CATREG analysis was conducted (Table 6). Notably, holistic soundscape evaluations were significantly effective in determining all the components ($p < 0.05$). Compared with appropriateness, subjective loudness and acoustic comfort were more crucial soundscape indicators.

To further account for the combined effects of sociodemographic and behavioral factors, holistic soundscape evaluations, and dominant sounds on PSR under individual and sound characteristics interactions, an additional CATREG analysis was conducted (Table 7). Comparatively, sociodemographic and behavioral factors were found to be more influential than sound characteristics, based on their importance index values. Specifically, visit duration and activity intensity were the strongest predictors of Fascination, Being-away-to, Being-away-from, and Compatibility. Meanwhile, holistic soundscape evaluations were more important in determining the Coherence and Scope. Additionally, visit frequency and occupation emerged as significant predictors for Scope. The tolerance value of the key determinants was higher than 0.2, indicating there were no co-linear relationships among the variables. Namely, the individual and sound related determinants were statistically meaningful.

These findings emphasize the importance of considering sociodemographic and behavioral characteristics in predicting the PSR for promoting health benefits in coastal blue spaces. It is worth noting that their influence on the PSR was even greater than that of the sound characteristics themselves. Therefore, a comprehensive approach that integrates sociodemographic, behavioral, and sound factors—tailored to specific restorative components—can help optimize the PSR in coastal blue spaces.

3.5 Characterization of PSR in Coastal Urban Spaces

Fascination, Being-away-to, Compatibility, Coherence, and Scope have been identified as the most suitable components for assessing the PSR when applied *in situ* within a specific environmental context[14]. This aligns with the findings of the present study, which further demonstrate that the PSR is influenced by a combination of sociodemographic, behavioral, dominant sound, and holistic soundscape factors. Theoretically, high scores across all PSR components are essential for fostering prolonged and effective psychological restoration, whereas low scores in any component may diminish the therapeutic potential of the environment. Therefore, it is also crucial to understand how PSR components contribute to the variance in PSR within coastal blue spaces. Such insights can aid in characterizing therapeutic landscape and identifying the key components that facilitate psychological restoration in terms of coastal soundscape.

To this end, a series of PRSS evaluations were analyzed

Table 6: Influence of holistic soundscape factors on PSR components

Components	Variable	Standardized coefficient		*DF*	*F*	*Sig.*	Importance	Tolerance	
		Beta	Std. error					After	Before
Fascination	Subjective loudness	−0.335	0.159	2	4.410	0.013	0.700	0.798	0.684
Being-away-to	Subjective loudness	−0.367	0.101	3	13.171	0.000	0.529	0.785	0.684
	Acoustic comfort	−0.300	0.088	3	11.531	0.000	0.359	0.815	0.656
Being-away-from	Subjective loudness	−0.336	0.159	2	4.461	0.013	0.723	0.742	0.684
	Acoustic comfort	0.156	0.086	2	3.286	0.040	0.261	0.678	0.656
Compatibility	Subjective loudness	−0.293	0.098	2	9.010	0.000	0.472	0.828	0.684
	Acoustic comfort	−0.330	0.104	2	10.015	0.000	0.441	0.800	0.656
Coherence	Subjective loudness	−0.346	0.150	3	5.335	0.001	0.892	0.939	0.684
Scope	Acoustic comfort	−0.213	0.103	3	4.255	0.006	0.763	0.730	0.656

Table 7: Combined influences of sociodemographic, behavioral, dominant sound, and holistic soundscape factors on PSR components

PSR component	Variable	Standardized coefficient		*DF*	*F*	*Sig.*	Importance	Tolerance	
		Beta	Std. error					After	Before
Fascination	Duration	0.313	0.110	2	8.144	0.000	0.316	0.870	0.787
	Education level	0.191	0.080	3	5.734	0.001	0.135	0.968	0.928
Being-Away-To	Duration	0.345	0.091	2	14.303	0.000	0.250	0.883	0.787
	Acoustic comfort	−0.409	0.105	3	15.470	0.000	0.196	0.596	0.562
	Subjective loudness	−0.361	0.126	3	8.188	0.000	0.185	0.652	0.641
Compatibility	Activity intensity	−0.282	0.070	1	16.242	0.000	0.224	0.886	0.929
	Subjective loudness	−0.276	0.112	2	6.021	0.003	0.175	0.876	0.641
	Acoustic comfort	−0.353	0.114	4	9.536	0.000	0.152	0.758	0.562
	Dominant sound	0.237	0.087	2	7.468	0.001	0.142	0.962	0.904
Coherence	Subjective loudness	−0.364	0.181	2	4.064	0.019	0.472	0.904	0.641
	Dominant sound	0.198	0.107	2	3.412	0.035	0.126	0.927	0.904
Scope	Acoustic comfort	−0.247	0.105	3	5.554	0.001	0.219	0.708	0.562
	Frequency	0.215	0.112	3	3.672	0.013	0.201	0.876	0.888
	Occupation	0.198	0.090	2	4.835	0.009	0.158	0.910	0.977

incorporating a combined assessment of individual and sound characteristics. The varimax rotated principal component analysis was employed to extract the orthogonal. With a criterion factor of eigenvalue > 1, 11 components were identified (Fig. 8). As shown in Table 8 (highlighted), 73.45% of the total variance were explained by the corresponding factors, representing a relatively high explanatory power, compared with previous environmental restorativeness studies, which have reported explained variance ranging from 33% to 70%[14,39].

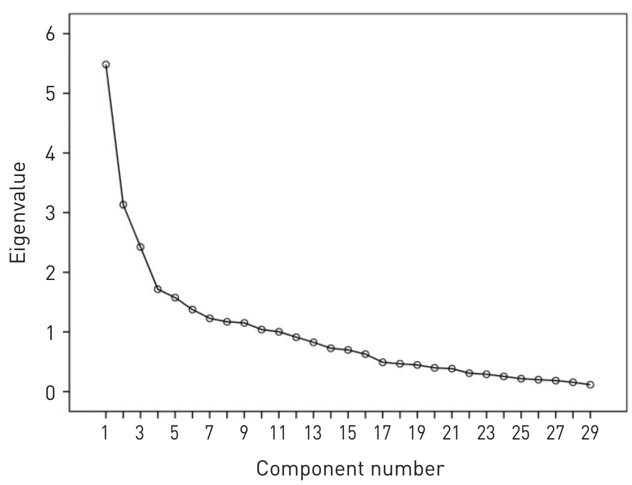


Fig. 8 Scree plot based on principal component analysis.

Note that factor 1 (12.98%) was most representative of Fascination, confirming its role as the primary driver of psychological restoration. Factor 2 (9.95%) was associated with Coherence, which can be understood as a key environmental affordance shaped by the unique coastal soundscape. Factors 3 (7.84%) and 4 (7.79%) corresponded to the restorative components of Being-away-to and Being-away-from, respectively. These findings highlight the necessity of supporting multi-dimensional functions within coastal environments to foster a sense of escape from daily stressors for a diverse range of visitors. Beyond the primary restorative components, factors 5 ~ 11 collectively explained 34.89% of the total variance, accounting for nearly half of the PSR

Table 8: Varimax rotated principal component analysis of PRSS evaluations and combined sociodemographic, behavioral, dominant sound, and holistic soundscape characteristics for PSR components (N = 201)

Extended restorative components	Factors/cumulative percent										
	1/ 12.98%	2/ 22.93%	3/ 30.77%	4/ 38.56%	5/ 46.17%	6/ 51.03%	7/ 55.76%	8/ 60.46%	9/ 65.00%	10/ 69.48%	11/ 73.45%
Fascination/AT	**0.885**	0.006	0.053	0.195	−0.028	−0.117	−0.007	0.056	0.005	−0.067	0.093
Fascination/LG	**0.821**	−0.170	0.101	0.098	−0.125	−0.092	0.042	−0.006	−0.071	0.083	−0.035
Fascination/WD	**0.756**	0.067	0.078	0.100	−0.063	0.407	0.138	−0.033	0.020	0.237	−0.068
Fascination/EG	**0.730**	0.092	0.082	−0.004	0.099	0.478	0.071	0.065	−0.008	0.112	−0.116
Fascination/AP	**0.728**	0.067	0.205	0.125	−0.053	−0.275	−0.019	−0.041	0.269	−0.223	0.125
Being-Away-To/DT	**0.565**	0.000	−0.090	0.460	0.211	0.078	0.176	0.272	−0.082	0.079	−0.061
Coherence/CH	0.000	**0.855**	0.071	0.085	−0.131	−0.017	0.075	−0.043	0.008	0.018	−0.078
Coherence/TG	−0.060	**0.769**	0.166	−0.014	−0.142	0.091	−0.115	0.124	−0.005	−0.043	−0.151
Coherence/BL	0.040	**0.723**	0.073	0.196	0.009	−0.083	0.267	0.004	0.257	0.034	0.053
Scope	−0.020	**0.714**	0.086	0.061	0.216	0.042	−0.135	0.191	−0.028	0.078	0.274
Being-Away-From/FR	0.140	0.157	**0.811**	0.171	−0.038	0.066	−0.184	−0.096	0.060	0.030	−0.115
Being-Away-From/BR	0.077	0.191	**0.774**	−0.009	−0.157	0.076	0.079	0.115	−0.037	0.029	−0.061
Compatibility/AC	0.165	−0.019	**0.587**	0.016	0.021	−0.040	0.464	0.368	−0.203	0.106	0.121
Being-Away-To/UH	0.096	0.175	0.114	**0.846**	−0.071	−0.014	−0.015	−0.041	0.019	−0.131	−0.061
Being-Away-To/DS	0.348	0.054	−0.003	**0.780**	0.012	0.109	0.116	0.117	−0.030	0.155	−0.051
Being-Away-From/DA	0.116	0.022	0.496	**0.564**	−0.073	0.150	−0.002	−0.169	0.218	0.023	0.053
Acoustic comfort	−0.023	−0.057	0.223	−0.105	**−0.807**	0.119	−0.076	−0.110	0.201	−0.021	0.088
Appropriateness	−0.030	−0.037	0.100	0.062	**0.785**	0.085	−0.084	−0.117	0.073	0.057	0.048
Subjective loudness	−0.058	−0.123	−0.135	−0.250	**0.748**	−0.028	−0.094	0.014	0.111	−0.076	0.032
Education level	0.019	0.050	0.147	0.107	−0.036	**0.755**	0.029	−0.129	−0.022	−0.100	0.077
Dominant sounds	0.091	0.018	−0.001	0.063	−0.130	0.047	**0.820**	−0.165	0.127	−0.165	−0.065
Compatibility/HI	0.228	0.350	−0.151	0.368	0.037	0.023	**0.428**	0.291	0.054	0.189	0.281
Activity intensity	−0.049	−0.112	−0.011	−0.031	0.047	0.095	0.109	**−0.729**	−0.105	−0.130	0.080
Compatibility/UT	0.035	0.401	0.380	−0.044	0.033	0.020	0.047	**0.485**	0.055	−0.253	0.061
Frequency	−0.094	0.162	−0.020	−0.021	0.199	−0.152	0.028	0.023	**0.737**	0.185	−0.095
Duration	0.224	−0.014	0.028	0.111	−0.343	0.191	0.143	0.200	**0.655**	−0.114	0.106
Gender	0.024	−0.042	0.011	0.031	0.000	0.004	−0.133	0.156	0.067	**0.768**	0.089
Visit aim	−0.155	−0.203	−0.139	0.032	−0.033	0.424	−0.082	0.179	−0.041	**−0.543**	0.061
Occupation	−0.011	0.000	−0.079	−0.076	−0.009	0.060	−0.011	−0.060	−0.020	0.051	**0.903**

NOTE

Kaiser-Meyer-Olkin measure of sampling adequacy (*KMO*) was 0.707 ($p < 0.05$); the cumulative percentage of variance explained was 73.45%; and factor extraction was based on eigenvalues greater than 1.

variance. Factor 5 (7.61%) was associated with holistic soundscape indicators, suggesting that overall soundscape quality plays a mediating role in the restorative experience. Namely, this finding suggested that holistic soundscape evaluations act as a bridge between key restorative components and individual characteristics. Factors 6 ~ 11 (27.28%) were linked to visitor demographics and visit behaviors, indicating that these factors explained a comparable portion of the variance in PSR. Notably, the restorative component of compatibility (Factors 7 and 8) was almost entirely mediated by individual characteristics, suggesting that personal behaviors interactively shape the perception of sound environment for psychological restoration. These results suggest a balanced contribution of PRSS, soundscape characteristics, and individual factors in predicting the PSR in coastal environments. The strong influence of individual behaviors features the importance of fostering connections between local communities and coastal environments to enhance psychological restoration. These insights highlight the need for a coordinated and optimized approach to developing therapeutic coastal urban spaces, ensuring that they effectively support diverse user needs while maintaining public health benefits.

4 Discussion

4.1 Theoretical Components of PSR in Coastal Urban Spaces

In this study, five reorganized theoretical components were identified, providing a robust framework for characterizing PSR (Table 8). Component 1 (12.98%) was associated with all PRSS items related to Fascination, making it the most influential driver of the PSR in coastal settings. Fascination reflects an environment's capacity to effortlessly capture attention. The coastal soundscape is not experienced in isolation; visual aesthetics, the dynamic and ever-changing nature of the coastline, the vast seascape, and the presence of engaging functional spaces all contribute to fostering Fascination. These multisensory restorative elements encourage prolonged engagement, enhancing the restorative experience. Component 2 (9.95%) was strongly associated with Coherence, which refers to the sense of being immersed in a "whole other world." In this context, the built environment in coastal urban spaces should provide a harmonious soundscape that aligns with the natural environment. The effectiveness of this harmony as a mediating factor between specific soundscape qualities of holistic soundscape evaluations and the PSR should be carefully considered (Table 7). Components 3 and 4 (15.63%) corresponded to the restorative components of Being-away-to and Being-away-from. The concept of Being away reflects an environment's ability to create a sense of distance from daily stressors and obligations, regardless of individual life circumstances or professional responsibilities. The findings of this study indicate that individuals with higher education levels and those employed in administrative, teaching, and medical professions reported significantly greater psychological restoration through being-away in blue spaces (Figs. 3 and 4). Previous research has shown that such individuals often prefer natural environments due to their ecological interests[40]. For the general public, extending visit duration (Table 5) and incorporating social and cultural experiences[39] may enhance perceptions of being away. Component 5 (9.43%) was linked to Compatibility, which reflects the degree to which an environment supports an individual's intended activities and meets environmental demands[41–42]. As indicated in Table 7, the interaction between public activities and the coastal soundscape plays a considerable role in determining Compatibility. Notably, higher restoration of Compatibility was appeared when low-intensity activities were connected with infrequent visits or when high-intensity activities were associated with frequent visits (Table 5). These findings suggest that visitors may experience greater restoration by utilizing different areas of the coast to minimize disturbances from other users. Consequently, the strategic design of functional systems within coastal environments—accounting for spatial (both physical and multisensory of seascape) and temporal (geological, seasonal, daily, and hourly) theoretical components—could shape restorative experiences by catering to diverse user needs.

4.2 Limitations and Prospects

4.2.1 Reflections of Field Investigation

PSR can be evaluated through either *in situ* surveys, or laboratory experiments. To prioritize the authenticity of the real coastal environment and ensure that the results reflect the general population with diverse sociodemographic and behavioral backgrounds, the present study relied on *in situ* investigation. However, as with any *in situ* study, certain limitations are inevitable.

For example, explanatory variables related to designed sound environments could not be fully integrated into the study. This research confirmed that holistic soundscape evaluations were correlated with the PSR, revealing that higher psychological restoration could be experienced with lower holistic soundscape evaluations (Figs. 5, 7). Nonetheless, according to ART, it would be expected that individuals would benefit from a quieter, more comfortable sound environment to clear their minds of daily cognitive "noise" and engage more deeply in restoration processes such as reflection[8,40]. Given that limited studies have specifically applied this theory to coastal urban space contexts, the current evidence on the impact of varying soundscapes is still inconclusive. Hence, it would be beneficial to analyze further effects of target variables (e.g., varied holistic soundscape evaluations, different spatial types) in experimental conditions, which has a great advantage in sufficiently applying changes to a soundscape, though this study has found that the influence of the sociodemographic and behavioural factors on the PSR could be even greater than that of the sound characteristics themselves.

4.2.2 Limitations and Further Research

First, as illustrated in 4.2.1, further research is needed to explore the effects of the target variables in controlled experimental settings, which would allow for more precise manipulation of the sound environment.

Second, although the findings of this study provide valuable insights into the variance explained in PSR, there are likely other specific landscape characteristics such as visual elements[43–44], internal bodily sensations[45], and sense of place[46–48] should be considered to fully account for the remaining variability, which were not examined in detailed in the presented study. Moreover, it is necessary to investigate additional characteristics in the preferences for the temperate environments of the coastal zone[5,26] and nature-based settings[34,44], as these can all simultaneously contribute to an optimization of the therapeutic landscapes. Investigating how these factors interact with the soundscape would also provide a more comprehensive understanding of PSR in such perceptual environments.

5 Conclusions

This empirical study investigated the role of individual and sound characteristics in interactively determining the PSR based on theoretical components—Fascination, Being-away-from and Being-away-to, Compatibility, and Coherence and Scope—through field questionnaire survey. The key findings are summarized as follows:

1) PSR significantly varied across occupations and education levels. Across all the PSR components, teachers/doctors consistently reported the highest restoration scores, and individuals with lower education levels tend to experience significantly lower PSR than those with high education levels.

2) PSR significantly varied according to behavioural patterns including visit purpose, duration, frequency, and activity intensity. Visitors motivated by mental restoration who stayed longer and engaged in lower-intensity activities with less frequent visits, or those who visited more frequently with higher-intensity activities, experienced higher PSR.

3) PSR significantly varied among different dominant sound types—natural, anthropogenic, and mechanical sounds—in relation to the PSR components. Significantly higher PSR was associated with the dominance of natural sounds such as sea waves or wind, while traffic noise led to significantly lower restoration scores.

4) Holistic soundscape evaluations were associated with all the PSR components. However, when combined interactions of individual and sound characteristics were considered, individual factors were also associated with all the components, and had greater influence than the sound characteristics in determining Fascination, Being-away-from and Being-away-to, and Compatibility, as indicated by the PSR prediction model.

5) Incorporating the PRSS with all PSR components, alongside individual and sound characteristics, a relatively robust structure was revealed that reflects the functioning of reorganized PSR components—Fascination, Coherence and Scope, Being-away-to and Being-away-from, sound characteristics, Compatibility, and individual demographics and behaviors. This framework covers the essential factors influencing psychological restoration in coastal soundscapes, with approximately half of the variance attributable to individual and sound characteristics. The variance explained by these factors reached 73.45%, which is a relatively high amount of explained variance compared with previous environmental restorativeness studies.

This study provides valuable empirical insights for promoting therapeutic landscapes by examining the functions, perceptions, and interactions within coastal built environments. It also enhances the understanding of and offers practical guidance for optimizing soundscapes in coastal blue spaces with public health benefits for psychological restoration.

Competing interests | The authors declare that they have no competing interests.

REFERENCES

[1] Foley, R., & Kistemann, T. (2015). Blue space geographies: Enabling health in place. *Health & Place*, *35*, 157–165.

[2] White, M., Wheeler, B., Herbert, S., Alcock, I., & Depledge, M. (2014). Coastal proximity and physical activity: Is the coast an under-appreciated public health resource? *Preventive Medicine*, *69*, 135–140.

[3] Etminani-Ghasrodashti, R., Paydar, M., & Ardeshiri, M. (2018). Recreational cycling in a coastal city: Investigating lifestyle, attitudes and built environment in cycling behaviour. *Sustainable Cities and Society*, *39*, 241–251.

[4] Zhai, W., Cheng, H., Gou, F., Wang, Z., & Li, Z. (2024). A meta-analysis of the impact of urban blue spaces on residents' mental health. *Landscape Architecture Frontiers*, *12*(5), 20–36.

[5] White, M., Smith, A., Humphreys, K., Pahl, S., Snelling, D., & Depledge, M. (2010). Blue Space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes. *Journal of Environmental Psychology*, *30*(4), 482–493.

[6] Bell, S. R., Phoenix, C., Lovell, R., & Wheeler, B. W. (2015). Seeking everyday wellbeing: The coast as a therapeutic landscape. *Social Science & Medicine*, *142*, 56–67.

[7] Kaplan, R., & Kaplan, S. (1989). The Experience of Nature: A Psychological Perspective. *Cambridge University Press*.

[8] Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Science*, *224*(4647), 420–421.

[9] Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*(3), 169–182.

[10] White, M. P., Pahl, S., Ashbullby, K., Herbert, S., & Depledge, M. H. (2013). Feelings of restoration from recent nature visits. *Journal of Environmental Psychology*, *35*, 40–51.

[11] Schafer, R. M. (1977). *The Tuning of the World*. A. A. Knopf.

[12] International Organization for Standardization. (2014). *Acoustics—Soundscape—Part 1: Definition and conceptual framework*.

[13] van Kamp, I., Klæboe, R., Brown, A. L., & Lercher, P. (2016). Soundscapes, Human Restoration and Quality of Life. In: J. Kang, & B. Schulte-Fortkamp (Eds.), *Soundscape and the Built Environment* (pp. 43–68). CRC Press.

[14] Payne, S. R. (2013). The production of a perceived restorativeness soundscape scale. *Applied Acoustics*, *74*(2), 255–263.

[15] Liu, F., Liu, P., Kang, J., Meng, Q., Wu, Y., & Yang, D. (2022). Relationships between landscape characteristics and the restorative quality of soundscapes in urban blue spaces. *Applied Acoustics*, *189*, 108600.

[16] Zhao, J., Xu, W., & Ye, L. (2018). Effects of auditory-visual combinations on perceived restorative potential of urban green space. *Applied Acoustics*, *141*, 169–177.

[17] Iyendo, T. O. (2017). Sound as a supportive design intervention for improving health care experience in the clinical ecosystem: A qualitative study. *Complementary Therapies in Clinical Practice*, *29*, 58–96.

[18] An, H., & Ren, X. (2025). *A systematic review on restorative perception research in China (2010–2024)*. 31st International Congress on Sound and Vibration (ICSV 2025), Incheon, Korea.

[19] Nicolosi, V., Wilson, J., Yoshino, A., & Viren, P. (2020). The restorative potential of coastal walks and implications of sound. *Journal of Leisure Research*, *52*(1), 41–61.

[20] Dinnie, E., Brown, K., & Morris, S. (2013). Community, cooperation and conflict: Negotiating the social well-being benefits of urban greenspace experiences. *Landscape and Urban Planning*, *112*, 1–9.

[21] White, M. P., & Dolan, P. (2009). Accounting for the richness of daily activities. *Psychological Science*, *20*, 1000–1008.

[22] Zhao, W., Li, H., Zhu, X., & Ge, T. (2020). Effect of birdsong soundscape on perceived restorativeness in an urban park. *International Journal of Environmental Research and Public Health*, *17*(16), 5659.

[23] Guo, X., Liu, J., Albert, C., & Hong, X. (2022). Audio-visual interaction and visitor characteristics affect perceived soundscape restorativeness: Case study in five parks in China. *Urban Forestry & Urban Greening*, *77*, 127738.

[24] Guo, X., Jiang, S., Liu, J., Chen, Z., & Hong, X. (2024). Understanding the role of visitor behavior in soundscape restorative experiences in urban parks. *Forests*, *15*, 1751.

[25] Huang, C. (2016). *Study on the social function of Dalian Urban Square* [Master's thesis]. Dongbei University of Finance & Economics.

[26] Yu, K. (2017). Coastal landscapes. *Landscape Architecture Frontiers*, *5*(4), 23–24.

[27] International Organization for Standardization. (2018). *Acoustics—Soundscape—Part 2: Data collection and reporting requirements*.

[28] Ren, X. (2023). Combined effects of dominant sounds, conversational speech and multisensory perception on visitors' acoustic comfort in urban open spaces. *Landscape and Urban Planning*, *232*, 104674.

[29] Ren, X., Tang, J., & Cai, J. (2022). A comfortable soundscape perspective in acoustic environmental planning and management: A case study based on local resident audio-visual perceptions. *Journal of Environmental Planning and Management*, *65*(9), 1753–1780.

[30] Ren, X., & Kang, J. (2015). Effects of visual landscape factors of ecological waterscape on acoustic comfort. *Applied Acoustics*, *96*, 171–179.

[31] Payne, S. R., & Guastavino, C. (2018). Exploring the validity of the perceived restorativeness soundscape scale: A psycholinguistic approach. *Frontiers in Psychology*, *9*, 2224.

[32] Niu, Y. (2024). *Restorative impact paths and enhancement strategies of urban coastal blue spaces* [Master's Thesis]. Dalian University of Technology.

[33] Ren, X., Du, S., Xue, Y., Yuan, M., & Shao, S. (2023). Study on audio-visual factors influencing the environmental quality of acoustic comfort of pedestrian streets with vehicular roads. *Building Science*, *39*(6), 109–116.

[34] Ren, X. (2019). Consensus in factors affecting landscape preference: A case study based on a cross-cultural comparison. *Journal of Environmental Management*, *252*, 109622.

[35] Xu, J., Wang, F., Chen, L., & Zhang, W. (2021). Perceived urban green and residents' health in Beijing. *SSM - Population Health*, *14*, 100790.

[36] Ren, X., Kang, J., Zhu, P., & Wang, S. (2018). Soundscape expectations of rural tourism: A comparison between Chinese and English potential

tourists. *The Journal of the Acoustical Society of America*, *143*(1), 373–377.

[37] Bishara, A. J., Li, J., & Conley, C. (2021). Informal versus formal judgment of statistical models: The case of normality assumptions. *Psychonomic Bulletin & Review*, *28*(4), 1164–1182.

[38] Meulman, J. (1997). *Optimal scaling methods for multivariate categorical data analysis, SPSS White Paper*. Data Theory Group of Social and Behavioral Sciences, Leiden University.

[39] Menatti, L., Subiza-Pérez, M., Villalpando-Flores, A., Vozmediano, L., & Juan, C. S. (2019). Place attachment and identification as predictors of expected landscape restorativeness. *Journal of Environmental Psychology*, *63*, 36–43.

[40] Lai, K. Y., Sarkar, C., Sun, Z., & Scott, I. (2020). Are greenspace attributes associated with perceived restorativeness? A comparative study of urban cemeteries and parks in Edinburgh, Scotland. *Urban Forestry & Urban Greening*, *53*, 126720.

[41] Paterson, M. (2009). Haptic geographies: Ethnography, haptic knowledges and sensuous dispositions. *Progress in Human Geography*, *33*(6), 766–788.

[42] Hu, X., Liu, X., Li, J., & Jiang, B. (2022). Creating restorative nearby green spaces for knowledge workers: Theoretical mechanisms, site evaluation criteria, and design guidelines. *Landscape Architecture Frontiers*, *10*(2), 9–35.

[43] Pazhouhanfar, M., & Kamal, M. S. M. (2014). Effect of predictors of visual preference as characteristics of urban natural landscapes in increasing perceived restorative potential. *Urban Forestry & Urban Greening*, *13*(1), 145–151.

[44] Ren, X., Kang, J., Zhu, P., & Wang, S. (2018). Effects of soundscape on rural landscape evaluations. *Environmental Impact Assessment Review*, *70*, 45–56.

[45] Ryan, A. (2016). *Where Land Meets Sea: Coastal Explorations of Landscape, Representation and Spatial Experience*. Routledge.

[46] Korpela, K. M., Ylén, M., Tyrväinen, L., & Silvennoinen, H. (2009). Stability of self-reported favorite places and place attachment over a 10-month period. *Journal of Environmental Psychology*, *29*(1), 95–100.

[47] Liu, Q., Wu, Y., Xiao, Y., Fu, W., Zhuo, Z., van den Bosch, C. C. K., Huang, Q., & Lan, S. (2020). More meaningful, more restorative? Linking local landscape characteristics and place attachment to restorative perceptions of urban park visitors. *Landscape and Urban Planning*, *197*, 103763.

[48] Meng, D., & Xu, L. (2023). Place attachment and healing environment: A study on the relationship between positive emotions and spatial types during campus closure. *Landscape Architecture Frontiers*, *11*(2), 10–32.

LAF | https://doi.org/10.15302/J-LAF-2026-0017
第14卷 / 第2期 / 260017 / 2026
收稿日期 | 2025-07-31 录用日期 | 2025-11-26
中图分类号 | TU986 文献标识码 | A

沿海城市空间使用者与声音特征如何交互决定声景恢复性体验——基于典型滨海环境场景的实证研究

任欣欣[1,*]，李昀昊[1]，刘涵默[1]，梅德热·托尼亚[2]

1 大连理工大学建筑与艺术学院，大连 116024
2 大连理工大学化工学院，大连 116024

*通信作者
地址：大连市甘井子区凌工路2号
邮编：116024
邮箱：renxinxin@dlut.edu.cn

摘要

声景恢复性是沿海城市环境健康效益的重要途径。然而，现有研究有限，且尚未结合使用者特征与声音特征对沿海城市空间声景的恢复性体验展开探讨。本研究将沿海城市空间作为基于自然的公众心理健康疗愈景观进行探索，并通过在中国典型滨海环境场景开展实地问卷调查，结合恢复性理论构成要素，探究个体与声音因素如何交互影响声景恢复性体验（perceived soundscape restorativeness，PSR）。研究发现：PSR呈现显著的个体异质性与声音特征依赖性，社会人口学特征、行为模式、主导声源与整体声景评价共同作用于PSR的形成机制。职业、教育水平、访问时长、频率及活动强度等个体因素与声景恢复性的全部4个理论要素——迷人、远离、兼容、程度——均相关。此外，个体因素对迷人、远离、兼容体验的影响比声音因素更重要。通过将理论要素与使用者及声音特征相整合，本研究借助声景恢复性测量量表（PRSS）扩展构建了一个稳健框架，用于解释沿海城市空间的声景恢复性体验。除理论要素外，声音特征与使用者特征可解释近半数总方差（73.45%）。本研究强调了恢复性理论要素、声音环境、社会人口学因素及行为活动在决定PSR中的显著交互作用。研究结果为优化滨海环境场景的声景及恢复性效益设计、提升其疗愈景观潜力及景观设计价值提供了实证依据。

关键词

沿海城市空间；社会人口学特征；行为模式；声景恢复性体验；声景评价；疗愈景观

文章亮点

- 结合使用者社会和行为特征探讨沿海城市空间的声景恢复性体验
- 相较于声音因素本身，使用者因素与更多的恢复性要素相关联
- 相较于声音因素的影响，使用者因素对声景恢复性的重要性更高
- 在多维因素交互作用下声景恢复性的理论构成要素被扩展和重组

基金项目

- 教育部人文社科基金项目（编号：23YJCZH176）
- 辽宁省经济社会发展研究课题（编号：2023lslybkt-029）