澳 門 科 技 大 學

MACAU UNIVERSITY OF SCIENCE AND TECHNOLOGY

內部通知

INTERNAL MEMORANDUM

致 To： 王冠強

由 From： 科研管理處 Research and Technology Administration Office

事由 Subject： 科研成果評鑑結果通知 Assessment outcome of academic research result

關於 閣下送交科研管理處作學術成果登記及評鑑的資料，依據《**澳門科技大學學術成果評鑑辦法2022**》進行評鑑，現通知 閣下有關學術成果評鑑結果如下：

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2025-12-04

Rule Sets for Identifying Conditional Attributes of Campus Green Spaces with Enhanced Mental Restoration Effect

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Abstract: The effect of creating green spaces on improving the mental well-being of university students has received increasing attention. Although previous studies have contributed some valuable discussions on what characteristics of green spaces a campus should provide, few have sought to explore the causal effects between conditional attributes of campus green spaces and mental restoration. To fill this gap, this study aimed to explore the causal rule sets for identifying conditional attributes of campus green spaces with enhanced mental restoration effects from a comprehensive perspective by using the fuzzy Delphi technique (FDT) and rough set analysis (RSA). As a result, 12 criteria were obtained by using FDT, and 6 key combination scenes that can cause different degrees of mental restoration were obtained by using RSA. This study not only contributes to the academic research of healthy campus green spaces but also provides new insights into the role of planning and maintaining campus green spaces. **DOI: 10.1061/JUPDDM.UPENG-5194**.

Author keywords: University students; Mental restoration; Campus green space; Causal rule; Comprehensive scenes.

Introduction

University students experience a psychologically sensitive period transitioning from adolescence to adulthood, when they face aggregated challenges of academic pressure, family detachment, new interpersonal relationships, and concerns about the future (Akhtar et al. 2020). This group shows a high prevalence of mental disorders. Studies have shown that university students worldwide have poorer mental health and higher morbidity rates of mental disorders, such as depression and anxiety, compared to the rest of society (Lei et al. 2016). Furthermore, unexpected extreme health crises, such as the COVID-19 pandemic, pose serious threats and impacts on people's physical and mental health worldwide, especially on the mental health of university students due to the forced changes in academic, social, and family situations (Nahar et al. 2022).

Conversely, a growing number of research studies have established a strong link between exposure to nature and improved mental health (Keniger et al. 2013). Numerous studies have demonstrated that green space is beneficial for health (Liu et al. 2022). While uncovering the mechanism behind the positive relationship between green space and health, these studies identified several benefits of green space, such as reduction of mental stress, enhancement of social cohesion, promotion of physical activity, mitigation of harmful environmental exposures (like air and noise pollution), advancement of personal development, and improvement of the immune system (Liu et al. 2022). However, these findings are based largely on observational studies of green spaces that are explicitly and specially designed to promote mental health; for example, healing gardens (Naderi and Shin 2008; Paraskevopoulou and Kamperi 2018; Sherman et al. 2005), which provide specific therapeutic benefits and are commonly found in hospitals.

Most recently, the effect of general green spaces on the improvement of the mental well-being of university students has received increasing attention (Lau and Yang 2009; Li et al. 2012; Liu et al. 2022; Marsh et al. 2020; Wang et al. 2016, 2019, 2021; Windhorst and Williams 2015; Xi et al. 2020). It is believed that open spaces with better natural landscapes on university campuses can play an important role in promoting and protecting the students' health as such environments make them feel safe, less stressed, more comfortable, and positively invigorated (Lau and Yang 2009). Research by Liu et al. (2022) demonstrated that green spaces on university campuses are effective in improving students' health, reducing mood disorders, and promoting psychological well-being. These findings underscore the importance of creating and maintaining green spaces on campus as a means to promote the mental health of university students. Previous studies have attempted to empirically investigate the restorative effects of creating green spaces as an intervention in the mental health of university students. For instance, Alvarsson et al. (2010) tested the effect of natural auditory stimuli on the psychological state of university students and found that natural sounds can facilitate recovery after experiencing psychological stress. A study focusing on

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the effect of color on the physical and psychological responses of university students found that certain colors were effective in reducing negative feelings and promoting vigor levels (Li et al. 2012). Xi et al. (2020) studied the effect of recreational activities on the physiological and psychological health of university students in different types of campus green spaces and found that four types of green space landscapes helped with university students' emotional anxiety and physical or mental fatigue to varying degrees. Among them, woodland and water landscapes were the most effective in improving concentration. These empirical studies confirmed the positive effects of variables such as quantity, type, and quality of the natural environment (sound, color, or style) on the physical and mental health of university students using controlled trials, individual reports, and so on.

In addition, some nonempirical studies discussed the quality of green space that benefits physical and mental health and provided site-specific suggestions for improvement (Jiang 2014; Lau et al. 2014; Paraskevopoulou and Kamperi 2018; Pouya and Demirel 2015; Rawlings 2017; Weerasuriya et al. 2019). Although most of these studies do not focus exclusively on university campus green spaces (e.g., some studied hospital healing gardens) and university students, they share similar mechanisms with respect to the contribution of university campus green spaces to mental health recovery. To some extent, they provide potential references for the development of quality assessment criteria of healthy university campus green spaces.

Although existing literature has contributed valuable discussions on what characteristics of green spaces a campus should provide, little has been said about the causal effects between conditional attributes of campus green spaces and mental restoration. To fill this gap, this study aimed to explore the causal rule sets for identifying conditional attributes of campus green spaces with enhanced mental restoration effects from a comprehensive perspective. An inductive analysis of the relevant literature and a fuzzy Delphi technique (FDT) were utilized to extract the potential conditional attributes of campus green spaces for mental health. Then, by using rough set analysis (RSA), the key combination scenes that can cause different degrees of mental restoration were obtained by using campus green spaces of three universities in Macao as cases. It is expected that this research will not only extend the academic research on cause-and-effect relationships between campus green spaces and mental health but also potentially contribute some suggestions for the design or improvement of campus green spaces for users' mental health promotion.

Potential Conditional Attributes of Campus Green Spaces for Mental Restoration

To formulate the potential criteria of campus green space quality with respect to its effect on university students' mental health, this section builds on the relevant empirical and nonempirical research literature that has identified the attributes of relevant green spaces (e.g., campus green spaces, healing garden, other urban landscapes) that could potentially have impacts on students' emotions or behaviors related to mental restoration. When discussing the characteristics of successful campus open spaces, Tourinho et al. (2021) mentioned two conceptual frameworks: one is the framework of successful public spaces, which contains four main dimensions of accessibility, sociability, comfort, and activities; the other is a framework based on people's needs in the urban landscape, which contains two dimensions, namely, nature needs (contact with nature, recreation and leisure, and aesthetic needs) and human-interaction needs (social interaction, citizen participation in the design process and community identity) (Matsuoka and Kaplan 2008). Based on these frameworks of behavioral demands for using such green spaces, six potential dimensions of healthy campus green spaces are categorized, namely, social interaction, comfort, accessibility, playfulness and interactivity, bonding with nature, and aesthetics. A total of 20 criteria are included under the six dimensions (Table 1).

Social Interaction

The sense of participation in various social activities in green spaces has been shown to have the ability to improve psychological well-being (Jiang 2014). A healthy green space with multiple choices of both open and private spaces for the needs of observing passersby and ensuring privacy of use (Naderi and Shin 2008) can provide users with a sense of control, which can lead to lower stress levels (Pouya and Demirel 2015; Rawlings 2017; Weerasuriya et al. 2019). Open and informal spaces are generally considered to stimulate creative expression, while intimate spaces have a mitigating effect on highly stimulated stress (Lau et al. 2014). Safety is also a crucial criterion; students may have concerns about outsiders accessing campus green spaces, which cast negative impacts on their sense of security and personal safety, particularly during late night hours (Marsh et al. 2020).

Comfort

Many relevant studies suggest the importance of providing a comfortable environment for users' health (Lau et al. 2014; Paraskevopoulou and Kamperi 2018; Weerasuriya et al. 2019). According to the literature, the comfort of green spaces depends on various factors, such as physical sensation, lighting, hearing, smell, and seating comfort (Lau et al. 2014; Paraskevopoulou and Kamperi 2018; Pouya and Demirel 2015; Weerasuriya et al. 2019). Weather is considered to be a restrictive condition that prevents people from using healing outdoor spaces, and some microclimate interventions under conditions such as too hot or rainy should be considered to improve the user's physical comfort and year-round enjoyment (Naderi and Shin 2008). Since students have different ideas of comfort, various choices of sunny and shaded spaces should be provided, depending on the different seasons and differences in students' preferences (Lau et al. 2014). Soft sounds from plants, insects, birds, or water can have a positive auditory impact and arouse interest (Ha and Kim 2021; Lau et al. 2014). Movable and diverse seating is recommended to be installed in rehabilitation green spaces to enhance comfort (Paraskevopoulou and Kamperi 2018). Nevertheless, negative effects in green spaces should be avoided, for instance, plants that produce excessively strong odors would create discomfort instead (Paraskevopoulou and Kamperi 2018).

Accessibility

Barrier-free design is helpful for various activities and the needs of both healthy pedestrians and disabled individuals (Jiang 2014; Paraskevopoulou and Kamperi 2018); disabled access should feature smooth materials and wheel-chair-accommodating width. For quick and easy access to campus green spaces, buffer zones near the entrance and connections with public transportation are important (Jiang 2014). Within the green spaces, circulation design should create a sense of order and direction (Lau et al. 2014). Well-organized walkways and clear spatial layouts are also desirable constituents. Green spaces should have flat and easily accessible paths, alternative walking routes, and well-organized space zones to reduce spatial complexity (Jiang 2014; Lau et al. 2014).

Table 1. Potential criteria for campus green spaces

Dimensions	Criteria	Descriptions of features	Sources
Social interaction	Spaces with a variety of enclosures and openness (C_1)	Design different types of spaces for privacy and social communication; private gardens should be designed for caregivers; hedgerows surrounding the seating area	Jiang (2014), Lau et al. (2014), Paraskevopoulou and Kamperi (2018), Pouya and Demirel (2015), Rawlings (2017), Weerasuriya et al. (2019), and Naderi and Shin (2008)
	Multipurpose spaces for multichoice flexible use (C_2)	Multidimensional design of green open spaces; design for different users' needs; an alternative space for staff and patients to work on therapy and opportunities to sit or lie down in the sun and sunbathe, sleep, read, write, or play	Jiang (2014), Lau et al. (2014), Paraskevopoulou and Kamperi (2018), Souter-Brown et al. (2021), and Weerasuriya et al. (2019)
	Surveillance spaces for social safety (C_3)	Surveillance space near children's playground; concerns about outside persons accessing certain areas on the university campus late at night had negative impacts on survey respondents' sense of security and personal safety	Jiang (2014) and Marsh et al. (2020)
Comfort	Microclimate (C_4)	Build shelter from the sun and glare; clustered trees and open grassy areas; various choices of sunny and shaded spaces; shading solid surface and maintaining breeze for creating a comfortable microclimate	Jiang (2014), Lau et al. (2014), Marsh et al. (2020), Paraskevopoulou and Kamperi (2018), Weerasuriya et al. (2019), and Naderi and Shin (2008)
	Comfortable seating (C_5)	Provide comfortable, movable, and diverse seating options; participants can choose where to place their choice of seating (beanbag, timber or metal bistro-style chair, or plastic armchair), near people, plants, or paths	Hami and Abdi (2021), Jiang (2014), Li et al. (2019), Paraskevopoulou and Kamperi (2018), Weerasuriya et al. (2019), and Naderi and Shin (2008)
	Natural sound (C_6)	Establish a calm and silent natural environment with comfortable sounds (e.g., sounds of running water)	Alvarsson et al. (2010), Ha and Kim (2021), Jiang (2014), Lau et al. (2014), Marsh et al. (2020), Paraskevopoulou and Kamperi (2018), Pouya and Demirel (2015), Rawlings (2017), Souter-Brown et al. (2021), Weerasuriya et al. (2019), and Naderi and Shin (2008)
	Sense of smell (C_7)	Aroma from plants to stimulate the sense of smell; avoid strong fragrances	Paraskevopoulou and Kamperi (2018) and Pouya and Demirel (2015)
Accessibility	Barrier-free (C_8)	Healing garden with disabled access; paths that have smooth materials and are wide enough for wheels; barrier-free design for both healthy pedestrians and disabled individuals	Jiang (2014), Paraskevopoulou and Kamperi (2018), Rawlings (2017), and Souter-Brown et al. (2021)
	Legible walking routes within the green spaces (C_9)	Circulation design should create a sense of order and direction; organized traffic and clear spatial layout; a choice of walking routes	Jiang (2014), Lau et al. (2014), Li et al. (2019), Paraskevopoulou and Kamperi (2018), Rawlings (2017), Weerasuriya et al. (2019), and Naderi and Shin (2008)
	Entrance and outward connections (C_{10})	Buffer zone near the entrance; close to public transportation at the park perimeter	Jiang (2014), Lau et al. (2014), Paraskevopoulou and Kamperi (2018), Pouya and Demirel (2015), Rawlings (2017), and Weerasuriya et al. (2019)
Playfulness and engagement	Spaces for physical activities (C_{11})	Spatial design encouraging physical activities; design of topography and paths to encourage therapeutic exercise; a boule track was provided to encourage activity	Jiang (2014), Lau et al. (2014), Marsh et al. (2020), and Paraskevopoulou and Kamperi (2018)
	Gardening (C_{12})	Design should consider horticultural activities that can provide positive distractions in the garden setting	Jiang (2014), Marsh et al. (2020), Paraskevopoulou and Kamperi (2018), and Pouya and Demirel (2015)
	Ecological education activities (C_{13})	Constructing wetlands or a water garden can provide opportunities to teach students about the biological processes, habitats, and importance of these ecosystems in nature	Lau et al. (2014) and Souter-Brown et al. (2021)
Bond to nature	Dense planting (C_{14})	Trees that are already large or will be large at maturity should be planted; a large number of plants in the garden provides a sense of amenity; spaces with high greenery coverage	Hami and Abdi (2021), Jiang (2014); Lau et al. (2014), Marsh et al. (2020), Paraskevopoulou and Kamperi (2018), Pouya and Demirel (2015), Weerasuriya et al. (2019), and Lee et al. (2024)
	Diverse planting (C_{15})	A variety of plants in various shapes, sizes, and textural diversity; garden with fruit trees, a variety of flower species or medicinal plants	Jiang (2014), Lau et al. (2014), Li et al. (2019), Paraskevopoulou and Kamperi (2018), Pouya and Demirel (2015), Weerasuriya et al. (2019), Naderi and Shin (2008), and Souter-Brown et al. (2021)
	Biodiversity (C_{16})	A flourishing habitat for fauna and flora; birds and other small animals; selecting native, adapted, and noninvasive species	Ha and Kim (2021), Lau et al. (2014), Pouya and Demirel (2015), Souter-Brown et al. (2021), and Weerasuriya et al. (2019)
	Waterscapes (C_{17})	Water and other natural elements; water gardens	Felsten (2009), Hami and Abdi (2021),

Table 1. (*Continued*.)

Dimensions	Criteria	Descriptions of features	Sources
			Lau et al. (2014), Paraskevopoulou and Kamperi (2018), and Sherman et al. (2005)
Aesthetics	Foci (C_{18})	Focal points to draw visual interest; an attraction that draws eyes and movement toward it; Foci can visually dominate and make a place distinct from its context; landmarks of the garden in relation to the ability to orient oneself within the garden	Jiang (2014), Lau et al. (2014), Paraskevopoulou and Kamperi (2018), and Weerasuriya et al. (2019)
	Interior–exterior visual order (C_{19})	Connecting with a background view (e.g., distant hills); visual connections from indoor to outdoor natural environments; amount of window view of nature; emphasizing design garden enclosure to enhance the sense of place	Lau et al. (2014), Paraskevopoulou and Kamperi (2018), Pouya and Demirel (2015), and Rawlings (2017)
	Cultural and spiritual features (C_{20})	Minimize ambiguity; foci in space mark places of cultural significance; art works with positive meanings; archetypal pattern of the contextual	Jiang (2014), Lau et al. (2014), Paraskevopoulou and Kamperi (2018); Pouya and Demirel (2015), and Naderi and Shin (2008)

Playfulness and Engagement

Based on the hypothesis that there may be a synergistic health benefit in participating in physical activities while being exposed to green spaces, some researchers have conducted empirical studies to investigate the positive effect of regular contacts with nature and participation in physical activity on mental health (Bowler et al. 2010). Some studies support the installation of physical activity spaces like fitness equipment and courts in health-oriented green spaces, including areas that encourage users to engage in rehabilitative exercises (Jiang 2014; Paraskevopoulou and Kamperi 2018). In interviews conducted by Marsh et al. (2020), respondents indicated that the ability of green spaces to attract students to get outside was a key criterion in determining their positive effect on mental health. Participation in gardening and ecological science outreach activities also has potential positive effects on psychological well-being (Jiang 2014; Lau et al. 2014; Souter-Brown et al. 2021). Xiu and Li (2006) suggested that gardening activities may lead to a state of mindfulness, which can promote feelings of well-being, total engagement, and forgetfulness of time and self. Souter-Brown et al. (2021) proposed that, given the low exposure and knowledge of nature among university students, the installation of science-based interpretation facilities in green spaces can contribute to the health promotion of green spaces.

Bond to Nature

As previously mentioned, numerous empirical studies have demonstrated the positive impact of exposure to nature on physical and mental health. Some studies have highlighted the relationship between the amount or density of green space and mental health. For example, Lee et al. (2024) suggested that the proportion of spaces with green material should be dominant for healing purposes (Pouya and Demirel 2015). In addition, some studies emphasized the diversity and attractiveness of plants (Souter-Brown et al. 2021; Paraskevopoulou and Kamperi 2018). Plants with different leaf shapes, colors, textures, and other features can provide attractive and distracting effects (Paraskevopoulou and Kamperi 2018). Recent research by Souter-Brown et al. (2021) found that spending just half an hour per week engaging in solitary or social activities in green spaces with abundant natural elements can significantly reduce work-related stress. Incorporating water-related criteria, such as ponds and waterfalls, into green spaces can provide users with relaxing and restorative experiences (Sherman et al. 2005; Jiang 2014; Lau et al. 2014).

Aesthetics

Weerasuriya et al. (2019) summarized the connections between visual stimulation/symbolic meanings provided by green spaces and some psychological experiences such as relaxation and refreshment. Qualitative results from Sherman et al. (2005) suggest that adolescents prefer open spaces with aesthetic features, modern design, historical elements, color, and so on. Accordingly, man-made features with aesthetic value in green spaces may have potential positive mental restoration impacts on university students. Focal points are areas or elements that hold visual domination, thereby making a place look distinct from its surroundings and helping people navigate better (Lau et al. 2014). Different forms of aesthetic artifacts are considered to have the potential to improve physical and mental health. Landscape artifacts with prominent forms attract visual interest, stimulate the senses, and change the ambiance of the environment (e.g., a calm and peaceful atmosphere) (Lau et al. 2014). The cultural and spiritual significance of a place could also be seen as adding positively to its health-promoting potential; for example, the use of local cultural elements could encourage people to empathize (Paraskevopoulou and Kamperi 2018). Additionally, the relationship between the green space and the surrounding buildings is important. Many scholars believe that window views can effectively contribute to the recovery of the physical and mental state of indoor users (Jiang 2014; Lau et al. 2014; Paraskevopoulou and Kamperi 2018; Weerasuriya et al. 2019). Public green spaces can provide natural visual stimulation to the surrounding buildings through windows (Lau et al. 2014). The visual connection between indoor and outdoor spaces contributes to the absorption of natural light and visual detachment from the man-made environment, which is recognized to have a positive effect on mental health (Rawlings 2017).

Comprehensive Assessment Model of Campus Green Space for Mental Health

Site Selection

Three universities in Macau (Fig. 1) were selected for this study, namely, the Macau University of Science and Technology (MUST), the University of Macau (UM), and the City University of Macau (CTU), based on the following reasons: (1) these universities all have green spaces that allow for surveys and are open to

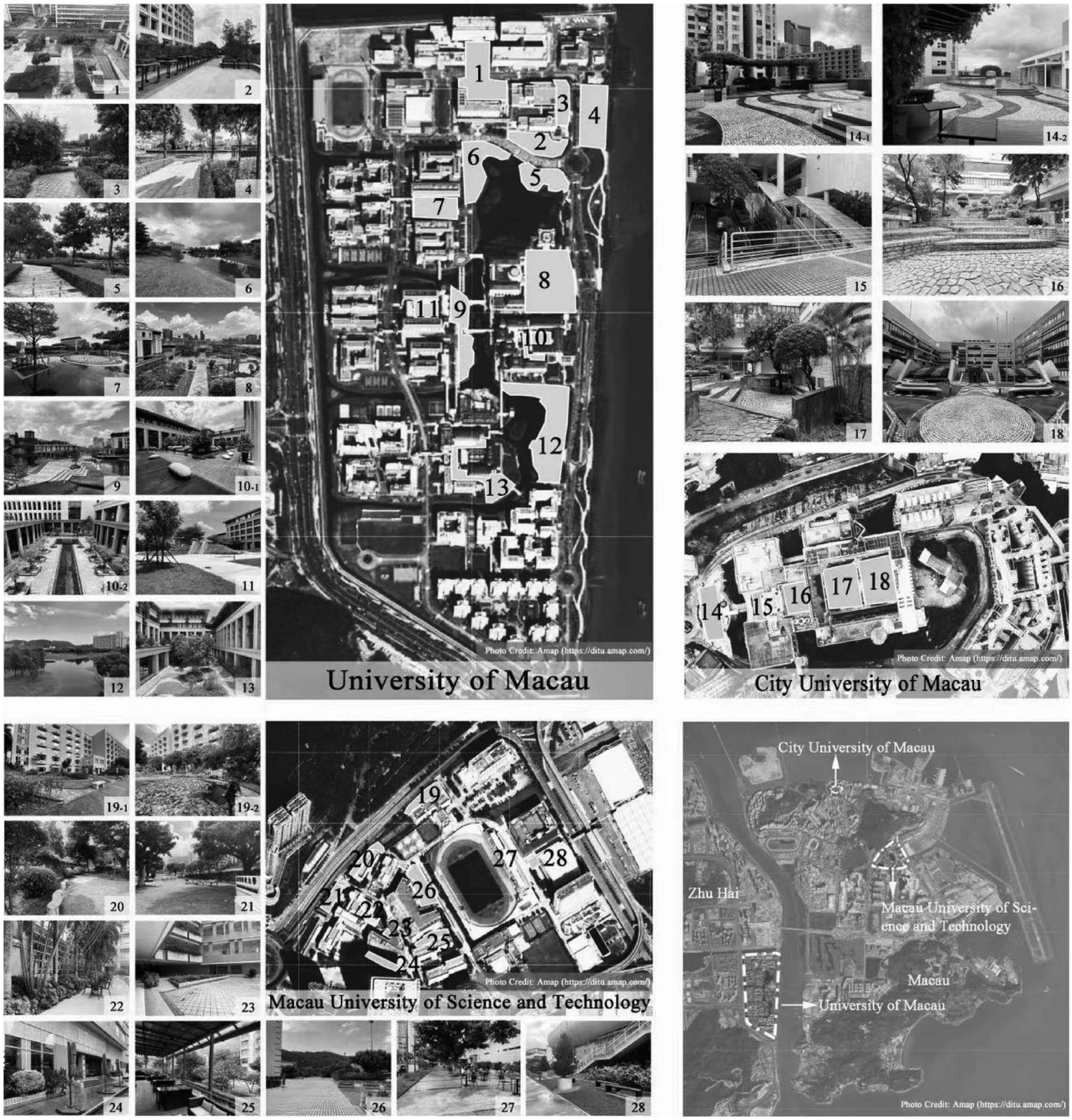

Fig. 1. Location of the three universities. (Satellite images © 2024 AmAP; images by Wei-Quan Zheng.)

public use by students; (2) these universities pay much attention to the mental health of their students and provide special courses and training activities every year to maintain students' mental health; and (3) the green spaces of these campuses contain diverse environmental characteristics and are a key part of the campuses to be improved and maintained year by year. Particularly, 28 green spaces in these three universities were earmarked for the study. The features of these 28 green spaces cover all the conditional attributes and also the key characteristics under each conditional attribute for further RSA (Table 4). Consequently, the green spaces of the three universities are suitable for this study. The location distribution and compositional characteristics of the selected green spaces are shown in Figs. 1 and 2.

Study Design and Methods

In recognition of the complexity and diversity of green spaces with respect to size, character, and associated function, it is recommended that quality judgment should reflect local needs (Gidlow et al. 2012). Hence, FDT is applied to obtain the local adaptiveness of each potential criterion of campus green spaces. Although the traditional Delphi method has been widely used

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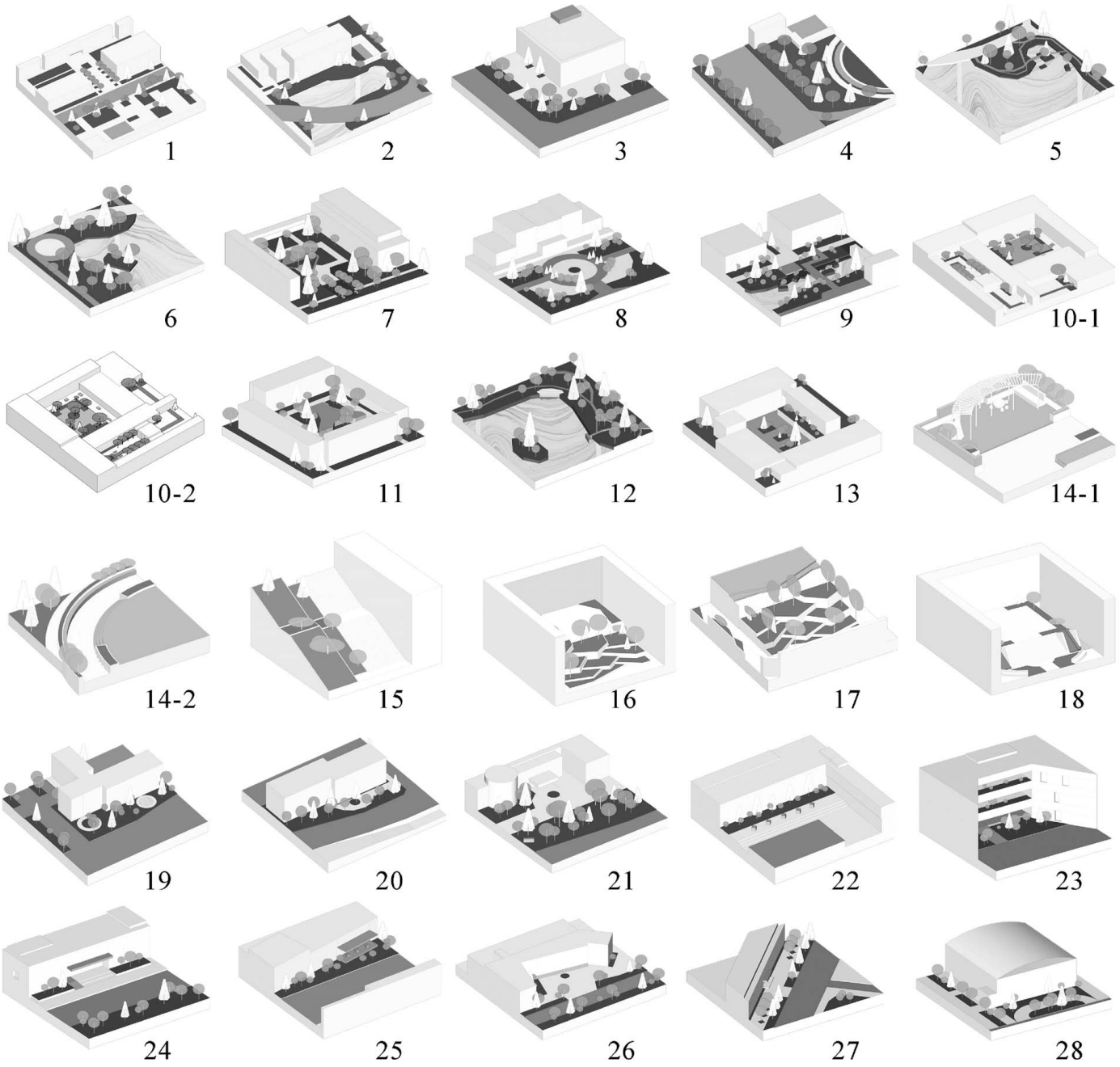


Fig. 2. Selected green space in this study. (Images by Xu Zhang and Guan-Qiang Wang.)

in various fields, it has the following shortcomings: (1) to achieve consensus among experts and a convergence effect, multiple questionnaires are often required, which is not only time-consuming and costly but also reduces the response rate; (2) when summarizing expert opinions, the person in charge of the plan may have preconceived notions and filter out the correct expert opinions, that is, systematically weaken or suppress different ideas; (3) taking the median and the middle 50% of the data as the range of expert opinions will ignore the opinions of the other half of the experts. Compared with the traditional Delphi method, FDT has the advantage of taking into account the opinions of all invited experts, which can save time and also reduce the round number of questionnaire distribution (Zhu et al. 2022). Following the study of Zhao et al. (2023) and Zhu et al. (2022), FDT in this study used the "double triangular fuzzy number" with a "gray zone verification method" to determine whether expert cognition demonstrates a consistent convergence effect.

To understand the "environmental response" rules between the environmental characteristics of campus green spaces and the degree of mental restoration, RSA was applied. RSA is a mathematical tool proposed by Pawlak in the 1980s. It applies data mining technology to screen out core evaluation indicators and clarify the knowledge of behavioral rules (i.e., if–then rules) behind the data. RSA can be used to solve the imprecise knowledge relationship between condition attributes and decision attributes in classification functions. It uses the exact set with equivalence relations to construct lower and upper approximation function sets to find the boundaries of the classification function. Based on this, the basic information is extended to obtain reduced attribute sets, core attribute sets, and knowledge rules. The simplification of the conditional attribute set is accomplished by

Table 2. Characteristics of respondents

Variables		$N=293$	Percentage (%)
Gender	Male	148	50.51
	Female	145	49.49
Age	18 years and below	27	9.22
	19–28	253	86.01
	29–38	13	4.44
	39 and above	1	0.34
Respondents in campus green spaces from	University of Macau (UM)	99	33.79
	Macau University of Science and Technology (MUST)	102	34.81
	City University of Macau (City U)	92	31.40
Type of activities you are mainly engaged in	Staying alone (resting, reading, waiting, enjoying the scenery, watching people, etc.)	91	31.06
	Participating in social activities (chatting with friends, discussing group assignments, outdoor courses, etc.)	75	25.60
	Participating in physical activities (e.g., walking or running)	64	21.84
	Passing through	57	19.45
	Else	6	2.05
How many years have you used the open spaces on this campus	Less than 1 year	28	9.56
	1–4 years	241	82.25
	5 years and above	24	8.19

calculating the importance of the conditional attribute through the degree of attribute dependence. Then, the core attribute set is retrieved from multiple reduced condition attribute sets. Finally, multiple behavioral rules are derived for each performance level within the decision attributes. Models based on rough set theory have the following advantages (Mckee 2000): (1) the rough set data analysis process results in the information contained in a large number of cases being simplified into a model containing a general description of knowledge; (2) a model is an easy-to-understand set of decision rules that usually requires no explanation; (3) each decision rule is supported by a set of real-world examples; and (4) no additional information is required, such as statistical probability or fuzzy set theory membership ranks.

Data Collection

According to the study design, data collection contains two parts. First, by using the FDT questionnaire, an expert survey was conducted from May 6 to June 7. All items of the questionnaire were rated on a 10-point Likert scale, ranging from 1 (completely unimportant) to 10 (completely important). The "most pessimistic cognitive value" and the "most optimistic cognitive value" were provided by all experts for each item. A total of 65 expert questionnaires were distributed in this study, of which 62 were returned. From the received responses, 59 questionnaires were valid. Three questionnaires were invalid due to incomplete answers. The respondents had professional backgrounds or experience in environmental design or landscape design research. Among them, 39 held a master's or doctorate degree, and 43 had at least 3 years of study or work experience in healthy landscape design. A total of 10 experts had work experience and had participated in related design industries in this field. Furthermore, 39 experts were academics in environment management and design. In sum, each of the experts had enough experience to participate in the survey on this issue.

The second part is the survey for RSA, and self-report questionnaires (Appendix SI) were distributed on-site. The survey instrument comprises three parts, namely, the demographic characteristics, conditional attributes, and decision attributes. As to conditional attributes, students are required to answer each question about conditional attributes based on their perception of the green space where they are. As to data collection for decision attributes, a self-report survey with eight items is used to measure the degree of mental restoration. Following the study of Luo et al. (2022), eight items under three dimensions (namely, restorative experiences, positive emotions, and stress reduction) were used to measure mental restoration experiences in green spaces. All descriptions were adapted to meet the purposes of this study. All items in decision attributes were rated on a three-point Likert scale ranging from "completely

Table 3. Results of FDT

Criteria	*Cu*	*Ol*	*Cm*	*Om*	*Gi*	Achieved the threshold?	Conditional attributes
Spaces with a variety of enclosures and openness (C_1)	8	6	5.2201	8.3694	6.9203	Yes	X_1
Multipurpose spaces for multichoice flexible use (C_2)	6	5	4.3708	7.5309	5.6084	No	—
Surveillance spaces for social safety (C_3)	7	5	5.3389	8.0786	6.2991	Yes	X_2
Microclimate (C_4)	8	6	5.9425	8.5363	7.1042	Yes	X_3
Comfortable seating (C_5)	8	6	5.1463	8.1130	6.8509	Yes	X_4
Natural sound (C_6)	8	6	5.1964	8.0476	6.8442	Yes	X_5
Sense of smell (C_7)	7	5	4.6138	7.3853	5.9998	No	—
Barrier-free (C_8)	8	6	4.9187	7.8073	6.7394	Yes	X_6
Legible walking routes within the green spaces (C_9)	8	6	4.7861	7.4935	6.6345	Yes	X_7
Entrance and outward connections (C_{10})	7	5	4.4512	7.5086	5.9920	No	—
Spaces for physical activities (C_{11})	9	6	4.6350	7.7847	6.8706	Yes	X_8
Gardening (C_{12})	7	5	4.0469	6.9990	5.8073	No	—
Ecological education activities (C_{13})	6	5	3.7301	6.9125	5.4573	No	—
Dense planting (C_{14})	7	5	4.0739	7.1012	5.8359	No	—
Diverse planting (C_{15})	8	6	4.8587	7.7028	6.7030	Yes	X_9
Biodiversity (C_{16})	6	5	4.3031	7.2940	5.5748	No	—
Waterscapes (C_{17})	8	5	4.8168	7.8525	6.4178	Yes	X_{10}
Foci (C_{18})	7	5	4.4732	7.4990	5.9945	No	—
Interior–exterior visual order (C_{19})	8	6	4.9017	7.8999	6.7602	Yes	X_{11}
Cultural and spiritual features (C_{20})	8	5	4.6570	7.7236	6.3468	Yes	X_{12}

Table 4. Condition and decision attributes for the RSA survey

Condition attributes (X)		Semantic scale (Key characteristics under each attribute)	Decision attributes (D)
X_1	Spaces with a variety of enclosures and openness	1 = The space is monotonic, for example, with merely one square or usable path 2 = Here are several options, including open spaces (like small vacant spaces) and private spaces (like resting spaces with green hedges) 3 = Here are different types of spaces with different degrees of openness, which are suitable for both solitary and social activities	A three-point scale from "strongly disagree" (1) to "strongly agree" (3). Q1: I feel restored after staying here. Q2: I forget everyday worries after staying here. Q3: Staying here gives me a break from my day-to-day routine. Q4: Staying here makes me happy. Q5: I feel energized after staying here for a while. Q6: I feel relaxed after staying here. Q7: Staying here makes me feel calm. Q8: Staying here helps me reduce stress.
X_2	Surveillance spaces for social safety	1 = The place makes me feel unsafe regardless of daytime or nighttime 2 = The place makes me feel unsafe during nighttime 3 = The place makes me feel safe at any time	
X_3	Microclimate	1 = Very hot, shadeless, scorching sunshine, hardly any wind 2 = Somewhat with shades (trees or sunproof roof available), but slightly hot still 3 = Here are different types of sunny and shaded spaces with breeze, which are very comfortable for me	
X_4	Comfortable seating	1 = Seating areas are scarce or locations are hardly convenient for use 2 = Seating areas (e.g., stairs or flower garden edges) are available, or in near-roadside locations, hence convenient to use 3 = Chairs are of different heights or with different materials (timber or metal chair, or plastic armchair), or in various locations (near people, plants or paths)	
X_5	Natural sound	1 = This place is a bit noisy (with the noises of people or cars). 2 = Generally, the environment here is relatively quiet. 3 = The environment here is silent and peaceful with comfortable natural sounds (e.g., sounds of water, birds)	
X_6	Barrier free	1 = The road surface is not smooth (with hollow pits or stepping stones) or excessively narrow 2 = The road surface is overall smooth, with moderate slopes, wide enough for wheels 3 = The road surface is smooth; paths have skidproof materials and are wide enough; for both healthy pedestrians and disabled individuals	
X_7	Legible walking routes within the green spaces	1 = With only one or two paths available for passage 2 = With a number of paths that are orderly and easy to navigate 3 = With roads of various widths or degrees of convenience available; I can easily navigate and have an interesting walk	
X_8	Spaces for physical activities	1 = Nearly no space available for sports activities 2 = With spaces available to walk or stand on 3 = With jogging paths or sports equipment	
X_9	Diverse planting	1 = With no variety in plants (just lawn or one or two types of trees) 2 = With a richer collocation (made up of several types of trees, woods, and grass plants) 3 = A variety of plants in various shapes, sizes, and textural diversity (e.g., a variety of flower species, medicinal plants, or fruit trees)	
X_{10}	Waterscapes	1 = No waterscape 2 = Here are several small-scale waterscapes (e.g., fishbowls, creeks, or ponds) 3 = Waterscapes with abundant water sources (e.g., rivers and creeks)	
X_{11}	Interior–exterior visual order	1 = Only able to view the inside of the venue; within the venue, the landscape is monotonic (only able to see the near-sight scenes) 2 = Able to see both the inside and the outside of the venue; able to see a collocation of near-sight and far-sight scenes 3 = Able to view multiple scenes at far, mid, and near-sight levels, even far-sight scenes outside the venue	
X_{12}	Cultural and spiritual features	1 = With no visual foci (like a sculpture or a highly recognizable scene) 2 = With visual foci (like a sculpture or special landscape) 3 = With visual foci and with positive cultural significances attached	

disagree" (1) to "completely agree" (3), with "neither agree nor disagree" (2) at the midpoint. The overall score level of the mental restoration for each respondent was divided according to the three grades corresponding to the mean value of these eight items.

The survey for RSA was conducted from September 15 to October 22, 2022. The questionnaire surveyed the performance of campus green spaces in terms of psychological stress relief on the three campuses, with the main question revolving around whether the respondents thought the green spaces on their current campus made them feel good in this regard. A total of 319 questionnaires were distributed through on-site surveys, and 308 survey responses were available for data analysis after excluding incomplete questionnaires. Ultimately, 293 questionnaires were valid and 3 questionnaires were decided to be invalid due to incomplete

Table 5. Accuracy and quality of classification

Class	No. of objects	Lower approximation	Upper approximation	Accuracy of classification	Quality of classification
$D=1$	76	28	74	0.7703	0.8703
$D=2$	183	176	211	0.8341	
$D=3$	43	22	46	0.4783	
Core attributes			X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}		

answers or the nonstudent status of the respondents. Table 2 provides a summary of the respondents' demographic information. Participants were mainly in the age group of 19–28 years ($n=253$, 86.01%), followed by 18 years and below ($n=27$, 9.22%). There were 148 males (50.51%) and 145 females (49.49%). "Type of activities you are mainly engaged in" and "How many years have you used the open spaces in this campus" were open-ended questions, and then the researcher clustered the answer types into a few aggregate categories that are likely to have quite different underlying mechanisms. The respondents of this study were mainly college students with a relatively high concentration of age ($n=253$, 86.01%). They were mainly engaged in "staying alone" activities such as resting, reading, waiting, enjoying the scenery, and watching people ($n=92$, 31.40%) in the green spaces. Most of the participants ($n=265$, 90.44%) have more than 1 year of experience using open spaces on their campuses. Accordingly, researchers believe that these respondents have extensive experience in the use of green spaces and have relatively stable perceptions and attitudes toward these familiar campus green spaces to support the corresponding mental restorative effects they experience here.

Results of FDT

By using analysis of FDT, eight criteria with consensus values (Gi) below six were eliminated due to their low importance (Table 3). From the results, 12 criteria achieved the threshold and were taken as the key assessment criteria. Then, these 12 criteria were marked as X_1-X_{12} for the condition attributes of the RSA survey in the next step (Table 4).

Results of RSA

To derive the causal rules between the environmental characteristics of campus green space and the level of mental recovery, the study employed ROSE2 software to perform RSA. The results, as presented in Table 5, indicate that the total average accuracy of the classification is 77.10% (±4.98%), meaning that the validity of the statistics is deemed acceptable. The quality value of the approximation of the condition attributes is 0.8703, which shows that 87.03% of the analyzed samples allow generating certain rules. As to core attributes, no condition attribute is excluded from the set of core attributes, suggesting that all the core attributes play an important role in mental recovery.

Through RSA analysis, 62 rules were obtained from the coded informational table. Among them, 9 apply to "low level of mental recovery" ($D=1$), 31 apply to "moderate level of mental recovery" ($D=2$), and 22 apply to "high level of mental recovery" ($D=3$). To interpret the rules, the threshold value of the percentage of training data is set as 10% for each decision class after consulting with experts. The rules of the "low level of mental recovery" ($D=1$) and the "high level of mental recovery" ($D=3$) whose proportion of training data covered by the rule is higher than 10% are considered, which yields six items. As presented in Table 6, if satisfying the collocation of certain states of certain condition attributes, then the green space users have the corresponding probabilities to achieve mental recovery of corresponding levels. For instance, Rule 6 indicates that if a student is located in a scene that satisfies $X_3=3$, $X_7=2$, $X_9=3$, and $X_{10}=2$ simultaneously, then the student will be enabled to enjoy a relatively high level of mental restoration; by contrast, Rules 1–5 indicate that if located in otherwise simultaneously collocated scenes, a student could enjoy a low level of mental restoration.

Discussion

Comprehensive Scenes from a Comprehensive Perspective

Campus green space landscapes are commonly viewed as a comprehensive unit, which comprises a plethora of landscape elements and features, for example, colors, forms, textures, fabrics, deepness, and other features (Hami and Abdi 2021). Therefore, comprehensive decision suggestions are more suitable for decision makers in environment design and management. The RSA analysis results provide both the key elements and the desirable comprehensive scenes composed of key elements from a comprehensive perspective for decision makers.

Table 6. Casual rules

No.	Conditions (C)	Decision (D)	Proportion of training data covered by the rule (%)	Number of matching cases
1	$X_3=2$ and $X_4=1$ and $X_8=1$ and $X_{11}=1$	$D=1$: Low level of mental recovery	17.91	12
2	$X_2=1$ and $X_6=1$ and $X_8=1$ and $X_{10}=1$ and $X_{11}=2$		14.93	10
3	$X_2=1$ and $X_4=1$ and $X_5=2$ and $X_9=1$ and $X_{10}=1$ and $X_{11}=1$		14.93	10
4	$X_1=1$ and $X_5=2$ and $X_{10}=1$ and $X_{11}=1$ and $X_{12}=1$		13.43	9
5	$X_2=1$ and $X_4=1$ and $X_6=2$ and $X_9=1$ and $X_{10}=1$ and $X_{11}=1$		14.93	10
6	$X_3=3$ and $X_7=2$ and $X_9=3$ and $X_{10}=2$	$D=3$: High level of mental recovery	18.60	8

Rule 6, one of the generated rules, characterizes the combinational features of campus green spaces (i.e., satisfying the following environment conditions: $X_3 = 3$ and $X_7 = 2$ and $X_9 = 3$ and $X_{10} = 2$, simultaneously) that could yield a high level of mental recovery. In this comprehensive scene, $X_3 = 3$ indicates the availability of various types of spaces with or without sunlight exposures and shades and the necessity of enabling the users to feel breezes. In a study on students' preferences for landscape campus scenes, Hami and Abdi (2021) investigated students' preferences for landscape campus scenes, and similarly, they found that the majority of these scenes had shadowing spaces. In the meantime, with respect to plant collocations in campus green spaces, it is indicated that for an optimal comprehensive scene, a necessary element ($X_9 = 3$) is a variety of plant collocations featuring plants of various shapes, sizes, textures, and kinds. Li et al. (2019) surveyed on students perceptions of campus green spaces. Their findings echoed the importance of the quality of the green space and emphasized the role of the species or layers of plants and the seasonal color richness in improving the attractiveness of green spaces and enhancing students' satisfaction. This study showed that a variety of plants in various shapes, sizes, and textural diversity is also an important condition in affecting students' mental recovery. Besides characterizing the features of green spaces, it is mentioned that in a comprehensive scene exists another essential condition for blue space. $X_{10} = 2$ indicates that a characteristic of water spaces is small-scale waterscapes. Felsten (2009) similarly revealed that scenes with water have a high restorative potential for the study break. Based on the questionnaire's tracing numbers, the researchers were able to trace back to the samples supporting such rules and identified their sources to be UM and MUST. At MUST, there are small-scale waterscapes such as fish ponds and lotus flowers grown in water tanks, while at UM, there exists a wide man-made lake and several interconnected creeks. Compared with previous studies, this study offers a more concrete characterization of waterscape features, namely, compared with wide man-made lakes, students are more inclined toward small-scale waterscapes (e.g., fishbowl, creek, or pond; see the 19th plot in Fig. 2); this is most likely because in the small-scale waterscapes of Macao campuses are more approachable and are often collocated with other fascinating elements such as carps or lotus flowers. At the same time, with respect to Legible walking routes within the green spaces (X_7), Speake et al. (2013) carried out focus group interviews with college students and discovered that in campus green spaces, the provision of signs, interpretation, and paths counts as an impactor for students' use and appreciation of green spaces. Lau et al. (2014) suggested that routes with various path forms and sequences should be considered for a campus. The scenes with a high level of mental recovery in this study highlight that "With a number of paths that are orderly and easy to navigate ($X_7 = 2$)" is a key condition for a green space. This emphasizes the easiness and convenience of roads and paths, rather than the leisure-oriented nature of paths with rich layers and shapes that previous studies said students liked. Hence, this study provides a new perspective to look into the differences in the findings.

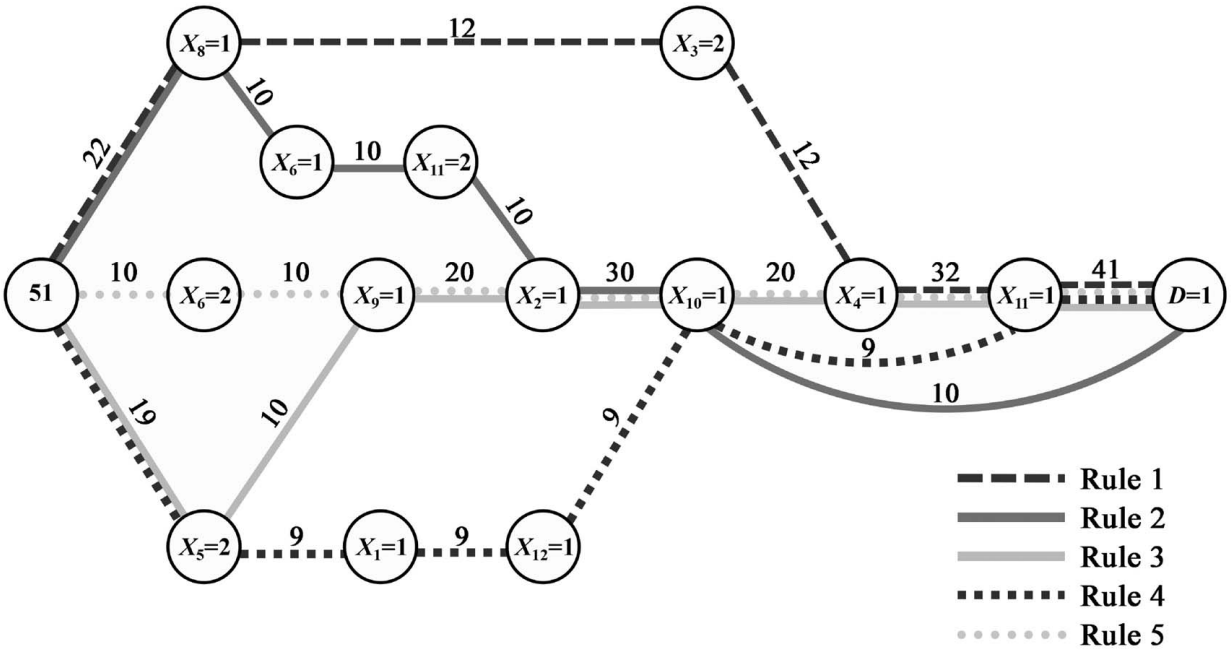
What this study emphasizes is comprehensive scenes that result from the aggregated efficacies of multiple elements and collocations, rather than the roles and functions of any single individual element. By tracing back to the samples supporting Rule 6, it is discovered that the eight samples (Nos. 21, 44, 52, 100, 126, 174, 181, 249) when addressing the question "The main activity you want to do in this green space is…" all chose the option of "walking through," which means that their main activity in green spaces is to pass through the green spaces to access other areas of the campus. To appeal to this need, it is suggested that to enable users to achieve high levels of mental recovery, a comprehensive scene must simultaneously satisfy the aforementioned multiple conditional attributes of green spaces. Hence, our findings depict some comprehensive scenes that can comprise multiple environmental attribute combinations for facilitating high-level mental recovery. This differs from previous studies, which emphasized the importance of a certain single element. By highlighting the compositional efficacies of environmental attributes, this study provides an opportunity to underscore the causal relationships between environment and mental recovery and therefore provides informing references for decision makers.

Rule Sets Supported by User Motives

Apart from the aforementioned compositional efficacies, this study made another interesting discovery, that is, the rule sets supported by similar user motives. Rules 1–5 mark five comprehensive scenes that lead to low-level mental recovery (Fig. 3). There exist several similar rules: Rule 1 and Rule 2, as well as Rule 3 and Rule 5.

As to Rule 1 and Rule 2, "Nearly no space available for sports activities ($X_8 = 1$)" is the same conditions in the two rules. When tracing back to the supporting samples of Rule 1 and Rule 2, it was found that among the supporting samples for Rule 1, when answering the question of "Type of activities you are mainly engaged in," eight respondents chose "Participating in physical activities" and four respondents chose "Staying alone," while the supporting samples of Rule 2 had nine choosing "Participating in physical activities" and one choosing "Participating in social activities." In other words, the majority of the supporting samples for both rules chose "participating in physical activities" to be their motive. Previous research studies focusing on exploring the pathways linking green space exposure to mental health have found significant evidence that revealed mediating effects of physical activities on the pathways from green space exposure on mental health. For example, physical activities in green spaces, such as cycling and running, can promote psychological recovery by providing users with a sense of achievement and a state of flow (Newman et al. 2014). Lou et al. (2023) found that natural physical activity can influence the gut–brain communication pathway, which can maintain physical stability and reduce the amount of stress. Herbert et al. (2020) verified the link between regular physical activity and cardiovascular health, mental health, and well-being in college students through research and demonstrated that short-term moderate-intensity aerobic exercise can help relieve depression and psychological stress in college students. The results also support the recommendations of Jiang (2014), Paraskevopoulou and Kamperi (2018), and Lau et al. (2014) to set up physical activity spaces in green spaces, including venues, fitness equipment, and courts that encourage users to engage in exercise. For guidelines for the design or improvement of campus green spaces, this study suggests that when responding to motives of physical activities, decision makers should attach importance to the provision of sports-friendly spaces for jogging or walks ($X_8 = 1$) and the smoothness of the road surfaces ($X_6 = 1$); in the meantime, it is also highly desired to provide shades in environments where physical comfort is valued ($X_3 = 2$), safeguard nighttime safety ($X_2 = 1$), facilitate visual pleasantness by providing pleasant view corridors and landscape layouts ($X_{11} = 1$, $X_{11} = 2$), and install some waterscapes if possible ($X_{10} = 1$).

Rules 3 and 5 constitute another rule set with similar motivation for use, in which the conditional attributes behave identically except for two conditions ($X_5 = 2$; $X_6 = 2$). Take the respondents' answers for "Type of activities you are mainly engaged in," for example, the majority of students chose "Staying alone (resting, reading, waiting, enjoying the scenery, watching people, and so on)," which accounts for 60% in Rule 3 and 50% in Rule 5.



X	Descriptions	Through flows
X_1=1	The space is monotonic, for example, with merely one square or usable path.	9
X_2=1	The place makes me feel unsafe regardless of daytime or nighttime.	30
X_3=2	Somewhat with shades (trees or sunproof roof available), but slightly hot still.	12
X_4=1	Sittable areas are scarce or locations are hardly convenient for use.	32
X_5=2	Generally, the environment here is relatively quiet.	19
X_6=1	The road surface is not smooth (with hollow pits or stepping stones) or excessively narrow.	10
X_6=2	The road surface is overall smooth, with moderate slopes, wide enough for wheels.	10
X_8=1	Nearly no space available for sports activities.	22
X_9=1	With no variety in plants (just lawn or one or two types of trees).	20
X_{10}=1	No Waterscape.	39
X_{11}=1	Only able to view the inside of the venue; within the venue, the landscape is	41
X_{11}=2	Able to see both the inside and the outside of the venue; able to see a collocation of near-sight and far-sight scenes.	10
X_{12}=1	With no visual foci (like a sculpture, or a highly recognizable scene).	9

Fig. 3. Decision flow graph of low-level mental recovery.

To respond to such motives, one should attach importance to easy-to-use, convenient seats (X_4). This is in line with the viewpoints of Hami and Abdi (2021) that seats play an essential role in campus landscape design. It is also important to create a sense of safety for the venue (X_2), which echoes the research findings of Ng and Chow (2023) that perceived insecurity impedes the use of green spaces. In the meantime, importance should also be attached to conditions such as diverse plants (X_9), waterscapes (X_{10}), and the interior–exterior visual order (X_{11}), which are related to provisions of visual pleasantness. The perspectives of "Detachment-Recovery" (Newman et al. 2014) provide a possible explanatory framework for the mechanisms behind the mental recovery from being alone in a campus green space. Studying continuously or engaging in interpersonal relationships with classmates strains students' psychological resources. Under these conditions, time away from study and social contact is essential for a return to a homeostasis set point or a mental baseline. According to the self-regulation model of ruminative thought, distraction techniques include cognitive strategies (e.g., attention switching and thought stopping) and behavioral strategies (e.g., engaging in new leisure activities requiring cognitive attention) (Newman et al. 2014). Therefore, students who are staying alone in campus green spaces can shift their attention, stop thinking, or engage in a new activity without social and studying pressures, which may produce positive effects on mental recovery.

Although the supporting samples for Rule 4 also chose "Staying alone" to be the motive, most answers to this open-end question from supporting samples for Rule 4 are "enjoying the scenery," which is different from the answers of "resting" provided by supporting samples for Rules 3 or 5. As a result, compared with Rules 3 and 5, the conditions mentioned in Rule 4 are mostly related to visual pleasantness. Following Rule 4, it is suggested that green spaces should afford paths with varied views that are fun to walk on (X_1); also, the layering of the landscape (X_{11}) is important, including adding some highly recognizable elements such as sculptures (X_{12}) and waterscapes (X_{10}), and it should avoid being excessively quiet (X_5). Rule 4 reveals the possibility that mental recovery enhancement can be achieved through only visual stimuli

from green spaces. Other research studies have hinted at such a finding. Li and Sullivan (2016) found that green window views in the classroom have significant, positive impacts on recovery of students from stress and mental fatigue. Sun et al. (2024) found that the ratio of natural elements to gray infrastructure in the window view affected college students' restorative benefits. Li and Sullivan (2016) attempted to understand the mechanisms behind the correlation between views of green campus landscapes and attentional functioning and stress levels from the perspectives of the attention-restoration theory (ART) and stress recovery theory (SRT). They claimed that the effect of green views of campus landscapes on attention restoration is "based on cognition and its effect is through human cognitive operations," whereas the effect of green views on stress recovery is "based on affect and its effect is through physiological responses to stress."

Gehl (2011) divided outdoor activities in public spaces into necessary activities, optional activities, and social activities. Each of these three categories of activities is thought to have very different demands on the physical environment. In this sense, passing through falls under necessary activities and participating in social activities (chatting with friends, discussing group assignments, outdoor courses, etc.) fall under social activities. These two kinds of activities are less dependent on the physical environment. Staying alone (resting, reading, waiting, enjoying the scenery, watching people, etc.) and participating in physical activities (e.g., walking or running) fall under optional activities, which depend highly on the quality of the physical environment. That is to say, when the quality of the outdoor areas is good, optional activities occur with increasing frequency. Thus, it is suggested that when resources are limited, priorities should be given to investing in the creation of environmental conditions for optional activities. If a high value is placed on mental recovery induced by sports activities, then attention should be paid to the creation of environmental conditions under Rules 1 and 2; nevertheless, if a high value is placed on mental recovery induced by nonsports activities, then focus should be placed on the creation of environmental conditions under Rules 3–5.

As such, the findings of this research not only help to understand better the cause–effect relations between campus green spaces and mental recovery but also provide insights into the different priorities for the improvement of compositional elements based on different motives.

Conclusions

A decision analysis model based on FDT and RSA techniques was constructed to explore campus green space environmental conditions that can enhance psychological recovery and to specifically analyze the collocation relationship between different campus green space environmental features and their effects on psychological recovery. This study presents theoretical and practical implications.

Theoretical Implications

This study extends the academic research on the cause-and-effect relationships between campus green spaces and mental health from a comprehensive perspective. Although existing studies have provided some valuable discussions on what characteristics campus green should have, few studies have attempted to provide a comprehensive assessment model for the quality of campus green spaces to promote mental health.

In studies exploring the relationship between campus green space and students' mental recovery, early studies focused on the impact of the presence or absence of green space, or the opportunity of students to see green space, on students' mental recovery (Li and Sullivan 2016). However, the specific characteristics of green spaces are rarely discussed in such studies. Some studies focused on providing a conceptual framework or design guidelines based on the researchers' observation and subjective induction analysis for open spaces in healthy campuses (Lau et al. 2014), healing gardens in a compact university campus (Lau and Yang 2009), and so on. Although discussions in these studies on the characteristics of campus green spaces are informative, the recovery effects of an environment with these characteristics are not supported by empirical evidence. What is more, some recent studies offer empirical support and describe in detail the relationship between the characteristics of green open spaces and mental recovery. These studies discuss the green spaces' characteristics such as perceived natural attributes and form (Liu et al. 2018), perceived sensory dimensions of green space (Malekinezhad et al. 2020), and objective environmental characteristic indicators, such as complexity, degree of naturalness, and environmental color (Sun et al. 2024).

However, these research studies presumed that this factor works independently and therefore did not consider the joint effect of sound in conjunction with other environmental factors. The Gestalt theory states that a perceiver blends diverse perceived features into a coherent and unitary impression by combining the meaning of individual components and their interrelationships, regardless of the nature of the experience (Kohler 1929). Based on the Gestalt approach, a perceiver in a green space derives holistic images by cognitively organizing various stimuli into groups.

By comparison, this study can contribute to providing evidence that can expand the causal relationship between the environmental characteristics of campus green spaces and the degree of students' mental recovery from a comprehensive perspective. Through reviewing the literature, 20 potential criteria for assessing the quality of healthy campus green spaces under 6 dimensions were summarized, and 12 key criteria were selected using the FDT-based expert consensus. Then, RSA was applied to understand the environment–recovery rules between the environmental characteristics of campus green spaces and degree of the mental restoration. Revealing these rules not only helps to determine the causal relationship between campus green space environments and psychological recovery but also provides insights into the prioritization of improving the constitutive conditions based on different motivations. A systematic understanding of the positive or negative effects of the collocation relationship between campus green space environmental features on the psychological recovery effect can help to complement and build on the empirical evidence of the relationship between campus green space environmental features and psychological recovery under the SRT perspective and provide a deeper understanding of the complex relationship between the two.

Managerial Implications

The results of this study can provide a reference for the design of campus green spaces in Macau or ones with similar contexts, and help managers and policymakers to make corresponding improvements to the green space in real-life management to promote users' health and well-being.

First, all the 12 conditional attributes are core attributes for mental recovery. From Fig. 3, it can be concluded that the attributes with larger through flows should be taken more into consideration for the design and improvement of campus green spaces. They are as follows: interior–exterior visual order (X_{11}), waterscapes (X_{10}), comfortable seating (X_4), surveillance spaces for social safety (X_2), diverse planting (X_9), and spaces for physical activities (X_8).

Second, this study can provide comprehensive scenes that are obtained from the aggregated efficacies of multiple elements and collocations, rather than the roles and functions of any single individual element. Decision makers can consider the following guidelines for comprehensive scenes practically:

1. In the comprehensive scenes (from Rules 1 and 2) mainly for physical activities in green spaces, designers should try to avoid the scene with the following characteristics: slightly hot spaces with fewer shade ($X_3 = 2$), lack of seat or seat locations that are hardly convenient for use ($X_4 = 1$), nearly no space available for sports activities ($X_8 = 1$), and monotonic views (only the near-sight scenes) ($X_{11} = 1$); and also the scene with perceived unsafe spaces ($X_2 = 1$), not smooth road surfaces or excessively narrow roads ($X_6 = 1$), nearly no space available for sports activities ($X_8 = 1$), no waterscape ($X_{10} = 1$), and views containing the inside and the outside of the site ($X_{11} = 2$).
2. In the comprehensive scenes (from Rules 3 and 5) mainly for resting alone, designers should try to avoid scenes with the following characteristics: perceived unsafe spaces ($X_2 = 1$), lack of seats or seat locations that are hardly convenient for use ($X_4 = 1$), relatively quiet ($X_5 = 2$), no variety in plants ($X_9 = 1$), no waterscape ($X_{10} = 1$), monotonic views ($X_{11} = 1$), and the road with overall smooth surface, and moderate slopes, wide enough for wheels ($X_6 = 2$).
3. In the comprehensive scene (from Rule 4) mainly for enjoying the scenery, designers should try to avoid the scene with the following characteristics: merely one square or usable path ($X_1 = 1$), relatively quiet ($X_5 = 2$), no waterscape ($X_{10} = 1$), monotonic views ($X_{11} = 1$), and no visual foci ($X_{12} = 1$).
4. In the comprehensive scene (from Rule 6) mainly for passing through, designers should try to provide the scene containing the following conditions: comfortable spaces with breeze and also choices of various sunny and shaded areas ($X_3 = 3$), a number of paths that are orderly and easy to navigate ($X_7 = 2$), abundant plants in various shapes, sizes, and textural diversity ($X_9 = 3$), and some small-scale waterscapes ($X_{10} = 2$), to obtain a high level of psychological recovery effect.

Third, in the case of an improvement project with a shortage of resources, decision makers can arrange multiple phases of gradual improvement in the following order: Guidelines 2 and 3, Guideline 1, and then Guideline 4, according to the degree of dependence of the target activities on green spaces.

Limitations and Future Research

There are also inherent limitations to this study.

First, 28 campus green spaces of three universities in Macao were selected for data collection for this study. Although the diversity and representativeness of the environmental characteristics of these spaces were taken into account, the results of the study could not be generalized to campus green spaces in a wider range of contexts due to differences in geographic, cultural, or other aspects of the campuses. Therefore, further studies could more extensively include campus green spaces in different regions and with different characteristics to provide more generalizable results.

Second, the mental restoration effect of each respondent in this study can be taken as the average self-perceived effect based on the user's perceived recovery experience accumulated multiple times in the same green space. However, some studies have found that the mental restoration effect can change over time in a single recovery cycle such as 9-min virtual reality (VR) immersion (Huang et al. 2020) and 5-min brief natural exposure (Ning et al. 2023). Future research should take the effect of change within a single recovery cycle into consideration when calculating the mental restoration effect.

Finally, this study did not provide a group analysis of samples and explore the effect differences across different demographic groups. However, the researchers have noted that some previous studies have found no significant difference in the mental health status of campus green space users using gender as a control variable (Malekinezhad et al. 2020). However, more detailed consideration of the effects of different cultural, age, gender, and other variables on the mental restoration effect should be conducted in future research, which will help this topic to unearth more valuable findings.

Data Availability Statement

The data used in this study are available from the corresponding author upon reasonable request.

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Supplemental Materials

Appendix SI is available online in the ASCE Library (www.ascelibrary.org).

References

Akhtar, P., L. Ma, A. Waqas, S. Naveed, Y. Li, A. Rahman, and Y. Wang. 2020. "Prevalence of depression among university students in low and middle income countries (LMICs): A systematic review and meta-analysis." *J. Affective Disord.* 274: 911–919. https://doi.org/10.1016/j.jad.2020.03.183.

Alvarsson, J. J., S. Wiens, and M. E. Nilsson. 2010. "Stress recovery during exposure to nature sound and environmental noise." *Int. J. Environ. Res. Public Health* 7 (3): 1036–1046. https://doi.org/10.3390/ijerph7031036.

Bowler, D. E., L. M. Buyung-Ali, T. M. Knight, and A. S. Pullin. 2010. "A systematic review of evidence for the added benefits to health of exposure to natural environments." *BMC Public Health* 10 (1): 456. https://doi.org/10.1186/1471-2458-10-456.

Felsten, G. 2009. "Where to take a study break on the college campus: An attention restoration theory perspective." *J. Environ. Psychol.* 29 (1): 160–167. https://doi.org/10.1016/j.jenvp.2008.11.006.

Gehl, J. 2011. *Life between buildings*. Washington, DC: Island Press.

Gidlow, C. J., N. J. Ellis, and S. Bostock. 2012. "Development of the neighbourhood green space tool (NGST)." *Landscape Urban Plann.* 106 (4): 347–358. https://doi.org/10.1016/j.landurbplan.2012.04.007.

Ha, J., and H. J. Kim. 2021. "The restorative effects of campus landscape biodiversity: Assessing visual and auditory perceptions among university students." *Urban For. Urban Greening* 64: 127259. https://doi.org/10.1016/j.ufug.2021.127259.

Hami, A., and B. Abdi. 2021. "Students' landscaping preferences for open spaces for their campus environment." *Indoor Built Environ.* 30 (1): 87–98. https://doi.org/10.1177/1420326X19887207.

Herbert, C., F. Meixner, C. Wiebking, and V. Gilg. 2020. "Regular physical activity, short-term exercise, mental health, and well-being among university students: The results of an online and a laboratory study." *Front. Psychol.* 11: 509. https://doi.org/10.3389/fpsyg.2020.00509.

Huang, Q., M. Yang, H.-a. Jane, S. Li, and N. Bauer. 2020. "Trees, grass, or concrete? The effects of different types of environments on stress reduction." *Landscape Urban Plann.* 193: 103654. https://doi.org/10.1016/j.landurbplan.2019.103654.

Jiang, S. 2014. "Therapeutic landscapes and healing gardens: A review of Chinese literature in relation to the studies in western countries." *Front. Archit. Res.* 3 (2): 141–153. https://doi.org/10.1016/j.foar.2013.12.002.

Keniger, L. E., K. J. Gaston, K. N. Irvine, and R. A. Fuller. 2013. "What are the benefits of interacting with nature?" *Int. J. Environ. Res. Public Health* 10 (3): 913–935. https://doi.org/10.3390/ijerph10030913.

Kohler, W. 1929. *Gestalt psychology*. New York: Liveright.

Lau, S. S. Y., Z. Gou, and Y. Liu. 2014. "Healthy campus by open space design: Approaches and guidelines." *Front. Archit. Res.* 3 (4): 452–467. https://doi.org/10.1016/j.foar.2014.06.006.

Lau, S. S. Y., and F. Yang. 2009. "Introducing healing gardens into a compact university campus: Design natural space to create healthy and sustainable campuses." *Landscape Res.* 34 (1): 55–81. https://doi.org/10.1080/01426390801981720.

Lee, R. J., Z. Xu, G. Newman, C. Lee, Y. Song, W. Sohn, D. Li, and Y. Ding. 2024. "Green infrastructure and community health: Exploring the characteristics of campus users in three university towns in Texas." *Cities Health* 1–14. https://doi.org/10.1080/23748834.2024.2381966.

Lei, X.-Y., L.-M. Xiao, Y.-N. Liu, and Y.-M. Li. 2016. "Prevalence of depression among Chinese University students: A meta-analysis." *PLoS One* 11 (4): e0153454.

Li, D., and W. C. Sullivan. 2016. "Impact of views to school landscapes on recovery from stress and mental fatigue." *Landscape Urban Plann.* 148: 149–158. https://doi.org/10.1016/j.landurbplan.2015.12.015.

Li, X., Y.-M. Lu, Z. Zhang, J. Wang, H.-T. Pan, and Q.-X. Zhang. 2012. "The visual effects of flower colors on university students' psychophysiological responses." *J. Food Agric. Environ.* 10 (3–4): 1294–1300.

Li, X., G. Ni, and B. Dewancker. 2019. "Improving the attractiveness and accessibility of campus green space for developing a sustainable university environment." *Environ. Sci. Pollut. Res.* 26: 33399–33415. https://doi.org/10.1007/s11356-019-06319-z.

Liu, Q., S. Luo, Y. Shen, Z. Zhu, X. Yao, Q. Li, M. W. K. Tarin, J. Zheng, and Z. Zhuo. 2022. "Relationships between students' demographic characteristics, perceived naturalness and patterns of use associated with campus green space, and self-rated restoration and health." *Urban For. Urban Greening* 68: 127474. https://doi.org/10.1016/j.ufug.2022.127474.

Liu, Q., Y. Zhang, Y. Lin, D. You, W. Zhang, Q. Huang, C. C. K. van den Bosch, and S. Lan. 2018. "The relationship between self-rated naturalness of university green space and students' restoration and health." *Urban For. Urban Greening* 34: 259–268. https://doi.org/10.1016/j.ufug.2018.07.008.

Lou, H., X. Liu, and P. Liu. 2023. "Mechanism and implications of pro-nature physical activity in antagonizing psychological stress: The key role of microbial-gut-brain axis." *Front. Psychol.* 14: 1143827. https://doi.org/10.3389/fpsyg.2023.1143827.

Luo, S., J. Shi, T. Lu, and K. Furuya. 2022. "Sit down and rest: Use of virtual reality to evaluate preferences and mental restoration in urban park pavilions." *Landscape Urban Plann.* 220: 104336. https://doi.org/10.1016/j.landurbplan.2021.104336.

Malekinezhad, F., P. Courtney, H. bin Lamit, and M. Vigani. 2020. "Investigating the mental health impacts of university campus green space through perceived sensory dimensions and the mediation effects of perceived restorativeness on restoration experience." *Front. Public Health* 8: 578241. https://doi.org/10.3389/fpubh.2020.578241.

Marsh, P., S. Mallick, E. Flies, P. Jones, S. Pearson, I. Koolhof, J. Byrne, and D. Kendal. 2020. "Trust, connection and equity: Can understanding context help to establish successful campus community gardens?" *Int. J. Environ. Res. Public Health* 17 (20): 7476. https://doi.org/10.3390/ijerph17207476.

Matsuoka, R. H., and R. Kaplan. 2008. "People needs in the urban landscape: Analysis of landscape and urban planning contributions." *Landscape Urban Plann.* 84 (1): 7–19. https://doi.org/10.1016/j.landurbplan.2007.09.009.

Mckee, T. E. 2000. "Developing a bankruptcy prediction model via rough sets theory." *Intell. Syst. Accounting Finance Manage.* 9 (3): 159–173. https://doi.org/10.1002/1099-1174(200009)9:3<159::AID-ISAF184>3.0.CO;2-C.

Naderi, J. R., and W.-H. Shin. 2008. "Humane design for hospital landscapes: A case study in landscape architecture of a healing garden for nurses." *HERD: Health Environ. Res. Des. J.* 2 (1): 82–119. https://doi.org/10.1177/193758670800200112.

Nahar, Z., M. Sohan, K. F. Supti, M. J. Hossain, M. Shahriar, M. A. Bhuiyan, and M. R. Islam. 2022. "Prevalence and associated risk factors for mental health problems among female university students during COVID-19 pandemic: A cross-sectional study findings from Dhaka, Bangladesh." *Heliyon* 8 (10): e10890. https://doi.org/10.1016/j.heliyon.2022.e10890.

Newman, D. B., L. Tay, and E. Diener. 2014. "Leisure and subjective well-being: A model of psychological mechanisms as mediating factors." *J. Happiness Stud.* 15: 555–578. https://doi.org/10.1007/s10902-013-9435-x.

Ng, H. K. S., and S. Y. Chow. 2023. "On the relationship between green space and civic engagement: The roles of well-being, outgroup trust, and activity level." *Am. J. Community Psychol.* 72 (1–2): 170–186. https://doi.org/10.1002/ajcp.12692.

Ning, W., J. Yin, Q. Chen, and X. Sun. 2023. "Effects of brief exposure to campus environment on students' physiological and psychological health." *Front. Public Health* 11: 1051864. https://doi.org/10.3389/fpubh.2023.1051864.

Paraskevopoulou, A. T., and E. Kamperi. 2018. "Design of hospital healing gardens linked to pre-or post-occupancy research findings." *Front. Archit. Res.* 7 (3): 395–414. https://doi.org/10.1016/j.foar.2018.05.004.

Pouya, S., and Ö. Demirel. 2015. "What is a healing garden?" *Akdeniz Univ. J. Fac. Agric.* 28 (1): 5–10.

Rawlings, T. S. 2017. "Beyond landscape: Development of a major healing garden." *Cardiovasc. Diagn. Ther.* 7 (3): 325–330. https://doi.org/10.21037/cdt.2017.01.02.

Sherman, S. A., J. W. Varni, R. S. Ulrich, and V. L. Malcarne. 2005. "Post-occupancy evaluation of healing gardens in a pediatric cancer center." *Landscape Urban Plann.* 73 (2–3): 167–183. https://doi.org/10.1016/j.landurbplan.2004.11.013.

Souter-Brown, G., E. Hinckson, and S. Duncan. 2021. "Effects of a sensory garden on workplace wellbeing: A randomised control trial." *Landscape Urban Plann.* 207: 103997. https://doi.org/10.1016/j.landurbplan.2020.103997.

Speake, J., S. Edmondson, and H. Nawaz. 2013. "Everyday encounters with nature: Students' perceptions and use of University campus green spaces." *Hum. Geographies–J. Stud. Res. Hum. Geogr.* 7 (1): 21–31. http://dx.doi.org/10.5719/hgeo.2013.71.21.

Sun, K., Z. Li, S. Zheng, and H. Qu. 2024. "Quantifying environmental characteristics on psychophysiological restorative benefits of campus window views." *Build. Environ.* 262: 111822. https://doi.org/10.1016/j.buildenv.2024.111822.

Tourinho, A. C. C., S. A. Barbosa, Ö. Göçer, and K. C. Alberto. 2021. "Post-occupancy evaluation of outdoor spaces on the campus of the Federal University of Juiz de Fora, Brazil." *Archnet-IJAR: Int. J. Archit. Research* 15 (3): 617–633. https://doi.org/10.1108/ARCH-09-2020-0204.

Wang, X., S. Rodiek, C. Wu, Y. Chen, and Y. Li. 2016. "Stress recovery and restorative effects of viewing different urban park scenes in Shanghai, China." *Urban For. Urban Greening* 15: 112–122. https://doi.org/10.1016/j.ufug.2015.12.003.

Wang, X., H. Zhu, Z. Shang, and Y. Chiang. 2019. "The influence of viewing photos of different types of rural landscapes on stress in Beijing." *Sustainability* 11 (9): 2537. https://doi.org/10.3390/su11092537.

Wang, Y., H. Qu, T. Bai, Q. Chen, X. Li, Z. Luo, B. Lv, and M. Jiang. 2021. "Effects of variations in color and organ of color expression in urban ornamental bamboo landscapes on the physiological and psychological responses of college students." *Int. J. Environ. Res. Public Health* 18 (3): 1151. https://doi.org/10.3390/ijerph18031151.

Weerasuriya, R., C. Henderson-Wilson, and M. Townsend. 2019. "A systematic review of access to green spaces in healthcare facilities." *Urban*

For. Urban Greening 40: 125–132. https://doi.org/10.1016/j.ufug.2018.06.019.

Windhorst, E., and A. Williams. 2015. "'It's like a different world': Natural places, post-secondary students, and mental health." *Health Place* 34: 241–250. https://doi.org/10.1016/j.healthplace.2015.06.002.

Xi, W., Z. Yanlong, R. Zhao, and L. Niu. 2020. "Study on the effects of four campus green landscapes on college students' physiological and psychological indicators." *Chin. Landscape Archit.* 36: 92–97.

Xiu, M. L., and S. Li. 2006. "A preliminary study of the influence of horticultural operation activities on the physical and mental health of the elderly." *Chin. Landscape Archit.* 22 (6): 46–49.

Zhao, L.-C., Y.-Y. Zheng, J.-Y. Lin, K. Shen, R.-T. Li, L. Xiong, B.-W. Zhu, and G.-H. Tzeng. 2023. "An ex-ante evaluation model of urban renewal projects for the sustainability potential towards TOD and AUD based on a FDEMATEL-GIS-FI approach." *Int. J. Inf. Technol. Decis. Making* 1–25. https://doi.org/10.1142/S0219622023500748.

Zhu, B.-W., Y. H. Xiao, W.-Q. Zheng, L. Xiong, X. Y. He, J.-Y. Zheng, and Y.-C. Chuang. 2022. "A hybrid multiple-attribute decision-making model for evaluating the esthetic expression of environmental design schemes." *SAGE Open* 12 (2): 215824402210872. https://doi.org/10.1177/21582440221087268.

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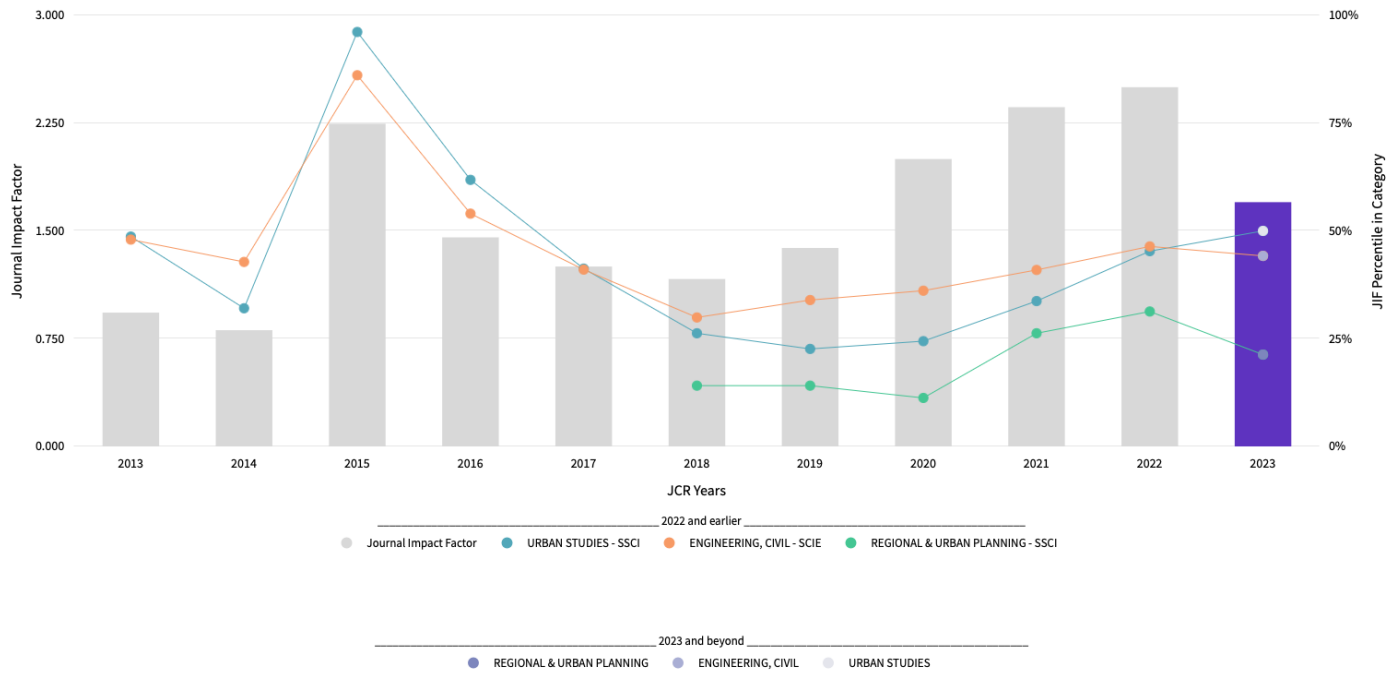

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CATEGORY

ENGINEERING, CIVIL

102/182

JCR YEAR	JIF RANK	QUARTILE	JIF PERCENTILE
2024	105/184	Q3	43.2
2023	102/182	Q3	44.2

CATEGORY

REGIONAL & URBAN PLANNING

43/54

JCR YEAR	JIF RANK	QUARTILE	JIF PERCENTILE
2024	38/55	Q3	31.8
2023	43/54	Q4	21.3

Rank by JIF before 2023 for ENGINEERING, CIVIL

EDITION

Science Citation Index Expanded (SCIE)

JCR YEAR	JIF RANK	QUARTILE	JIF PERCENTILE
2022	75/139	Q3	46.4
2021	82/138	Q3	40.94
2020	88/137	Q3	36.13
2019	89/134	Q3	33.96
2018	93/132	Q3	29.92
2017	76/128	Q3	41.02
2016	58/125	Q2	54.00
2015	18/126	Q1	86.11
2014	72/125	Q3	42.80
2013	65/124	Q3	47.98

Rank by JIF before 2023 for REGIONAL & URBAN PLANNING

EDITION

Social Sciences Citation Index (SSCI)

JCR YEAR	JIF RANK	QUARTILE	JIF PERCENTILE
2022	28/40	Q3	31.3
2021	30/40	Q3	26.25
2020	36/40	Q4	11.25
2019	34/39	Q4	14.10
2018	34/39	Q4	14.10
2017	N/A	N/A	N/A
2016	N/A	N/A	N/A
2015	N/A	N/A	N/A
2014	N/A	N/A	N/A
2013	N/A	N/A	N/A

CATEGORY

URBAN STUDIES

39/77

JCR YEAR	JIF RANK	QUARTILE	JIF PERCENTILE
2024	38/76	Q2	50.7
2023	39/77	Q3	50.0

Rank by JIF before 2023 for URBAN STUDIES

EDITION

Social Sciences Citation Index (SSCI)

JCR YEAR	JIF RANK	QUARTILE	JIF PERCENTILE
2022	24/43	Q3	45.3
2021	29/43	Q3	33.72
2020	33/43	Q4	24.42
2019	33/42	Q4	22.62
2018	30/40	Q3	26.25
2017	24/40	Q3	41.25
2016	15/38	Q2	61.84
2015	2/39	Q1	96.15
2014	27/39	Q3	32.05
2013	20/38	Q3	48.68

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CATEGORY

ENGINEERING, CIVIL

84/182

JCR YEAR	JCI RANK	QUARTILE	JCI PERCENTILE
2024	88/185	Q2	52.70
2023	84/182	Q2	54.12
2022	72/179	Q2	60.06
2021	77/175	Q2	56.29
2020	91/172	Q3	47.38
2019	77/172	Q2	55.52
2018	80/170	Q2	53.24
2017	63/168	Q2	62.80

CATEGORY

REGIONAL & URBAN PLANNING

38/54

JCR YEAR	JCI RANK	QUARTILE	JCI PERCENTILE
2024	39/55	Q3	30.00
2023	38/54	Q3	30.56
2022	32/54	Q3	41.67
2021	33/53	Q3	38.68
2020	38/51	Q3	26.47
2019	36/51	Q3	30.39
2018	35/51	Q3	32.35
2017	N/A	N/A	N/A

CATEGORY

URBAN STUDIES

44/77

JCR YEAR	JCI RANK	QUARTILE	JCI PERCENTILE
2024	49/77	Q3	37.01
2023	44/77	Q3	43.51
2022	39/77	Q3	50.00
2021	42/76	Q3	45.39
2020	46/72	Q3	36.81
2019	40/72	Q3	45.14
2018	40/71	Q3	44.37
2017	30/70	Q2	57.86

CATEGORY

PLANNING & DEVELOPMENT

N/A

JCR YEAR	JCI RANK	QUARTILE	JCI PERCENTILE
2024	N/A	N/A	N/A
2023	N/A	N/A	N/A
2022	N/A	N/A	N/A
2021	N/A	N/A	N/A
2020	N/A	N/A	N/A
2019	N/A	N/A	N/A
2018	N/A	N/A	N/A
2017	28/48	Q3	42.71